28-4-93
2 8 13 24
40 54 56 64
67 72

RADIO · TEST EQUIPMENT · COMPUTERS · AUDIO

No. 66

FULL SOR

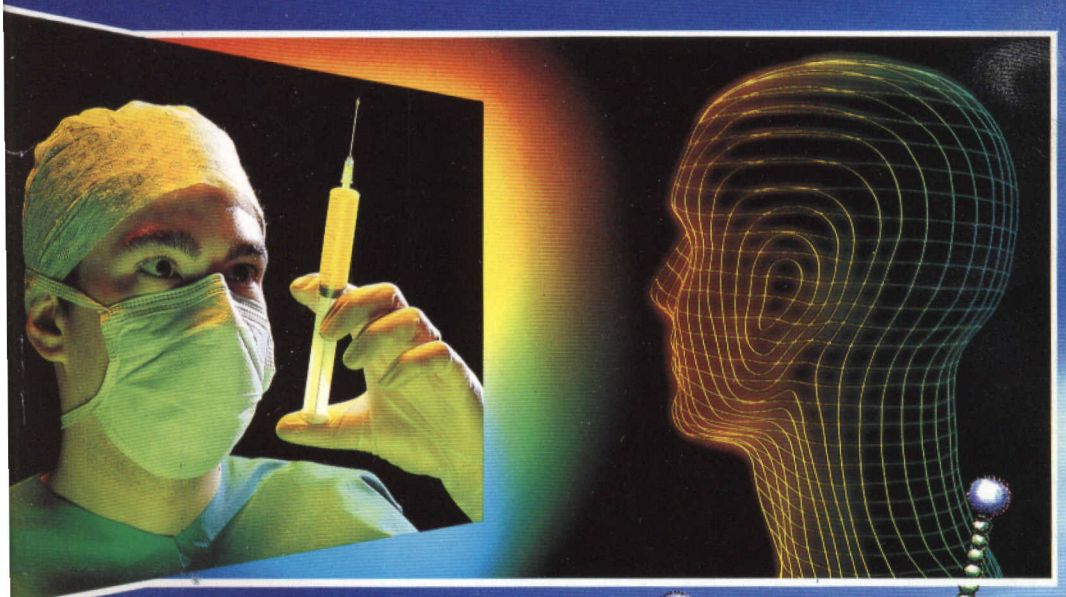
ELECTRONICS

The Maplin Magazine

Britain's Best Selling Electronics Magazine

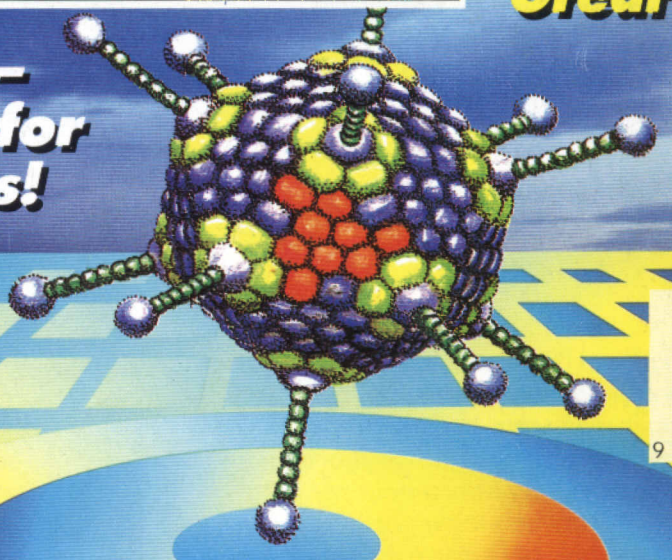
JUNE 1993 £1.95

Printed in the United Kingdom



Build a Torch Finder, a PC Opto Card, an Audible Logic Probe, a Digital & Analogue Development Unit, plus other Great Projects!

Computer Viruses – Essential Reading for All Computer Users!



9 770957 545053 06

How to Use Professional Audio Equipment, Troubleshoot Digital Circuits, and much more!

COMPUTER SHOPPER show

SAVE! £1.50 DISCOUNT ON ENTRANCE FEE!

JUNE 1993
VOL.12 No.66

IN THIS ISSUE...

PROJECTS FOR YOU TO BUILD!

IBM PC OPTO-ISOLATOR CARD This versatile project provides your IBM PC or compatible with eight opto-isolated inputs and eight opto-isolated outputs. It's easily controlled from BASIC too! 8

ANALOGUE & DIGITAL DEVELOPMENT UNIT You name it, this unit's got it! Multi-output fixed and variable power supply, logic indicators, switched logic outputs, oscillator... Just the ticket! 24

TORCH LOCATOR Power cut or fuse blown... lost in the darkness... this simple project will come to your aid! In the event of a power failure, the unit lights up and guides you to a nearby torch. 40

AUDIBLE TTL LOGIC PROBE Keep your eyes on the circuit under test with this easy to build project. Low or high pitch tones are emitted to indicate logic level. 54

12V DC TO 240V AC INVERTER Power mains appliances from a 12V supply by using this ingenious unit. Ideal for caravanning, or the basis of an uninterruptible power supply. 64

6/12 CHANNEL MODULAR MIXER How to combine all of the mixing modules described so far to make a 6 or 12 channel mixer. 72

FEATURES ESSENTIAL READING!

STOP PRESS . . . 'Electronics' Exclusive! Madame Tussaud's new high tech dark ride opens soon in London. 4

ALL ABOUT COMPUTER VIRUSES If you use computers then you are at risk from computer viruses. Read this 'essential' feature by Frank Booty to find out more! 16

INCIDENT COMMAND VEHICLE Find out all about an ingenious crowd control and mobile security vehicle that features a wealth of high tech special equipment. 32

THE HISTORY OF COMPUTERS A light-hearted look at the development of the modern computer. 44

CITIZEN LCD MONITOR REVIEW If you're worried about the possible long-term effects of using conventional VDUs, then perhaps this new monitor from Citizen is right up your street. 45

INDUSTRIAL ELECTRONICS ASSEMBLY Keith Brindley reveals how electronic products are assembled using modern manufacturing techniques. 48

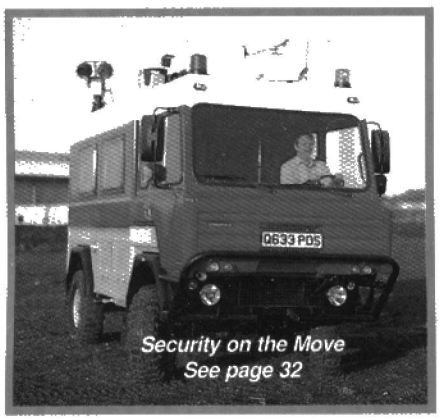
HOW TO TROUBLESHOOT DIGITAL CIRCUITS If your latest digital masterpiece fails to work, how do you find out what's gone wrong? Graham Dixey has the answers in this hands-on fault-finding feature. 56

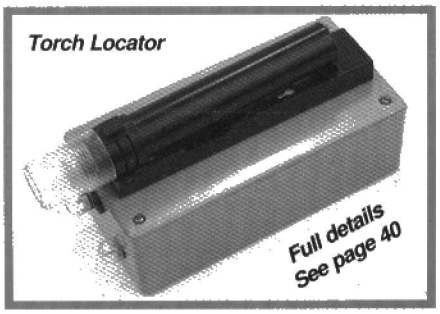
YOUNG RADIO HAMS START HERE. . . It's now easier than ever to become a licensed radio amateur, Ian Poole explains how. 61

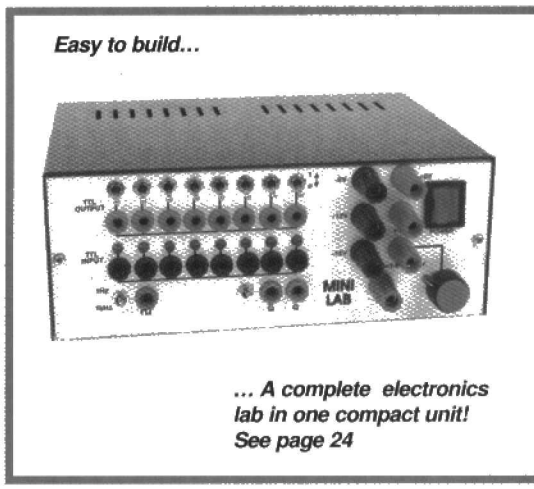
UNDERSTANDING AND USING PROFESSIONAL AUDIO EQUIPMENT With BBC engineer Tim Wilkinson, continuing his explanation of microphone types and techniques. 67

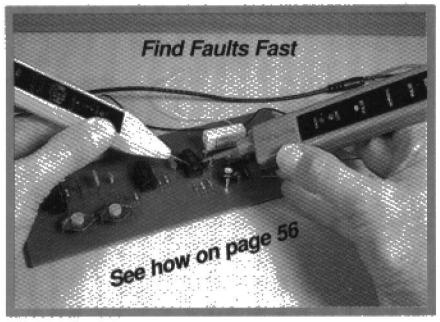
REGULARS NOT TO BE MISSED!

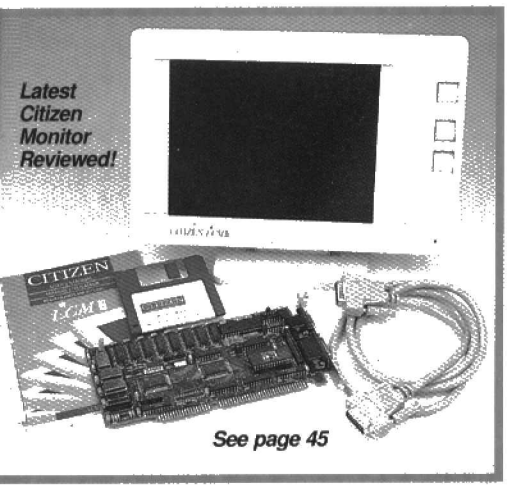
ABOUT THIS ISSUE...	2	NEWS REPORT	6	READERS LETTERS	23
TECHNOLOGY WATCH	3	TOP 20 KITS/ NEXT ISSUE	20	STRAY SIGNALS	39
NEWS EXTRA	4	HOW TO SUBSCRIBE	21	CLASSIFIED ADVERTS	71
BRANDS HATCH COMPETITION	5	ORDER COUPON	22	TOP 20 BOOKS	80

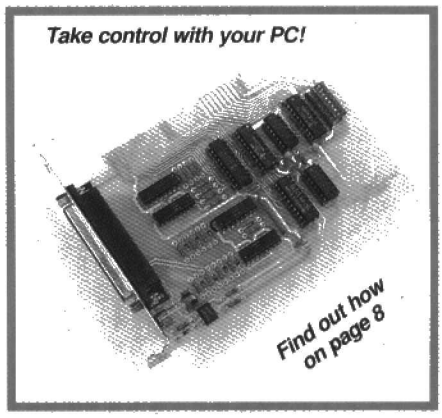












ABOUT THIS ISSUE. . .

Hello and welcome to this new style issue of 'Electronics'!

Since December 1988, the design of the contents page and front cover of 'Electronics' has remained largely the same, so we felt it was high time for a change! The cover designs (which actually changed two issues ago for those of you who didn't notice!), are brighter and more colourful; it should make 'Electronics' easier to find on newsagents' shelves! The contents page now has more space devoted to telling you what's 'in this issue' and all that 'small print' has been carried over to this page. After all, if it's worth including, you ought to be able to actually *read* it! Based on commonly asked questions from readers, there's loads of new information included as well; explaining the meaning of Project Ratings, how to get technical help, how to order components, etc.

If you're into computers, then you will probably want to visit the Computer Shopper Show which runs from 20th to 23rd May at Olympia, London. You will find a £1.50 off entrance fee voucher in the News Report on pages 6 and 7, just the ticket!

There's the chance to fulfil that driving ambition in this months super competition – Go Racing at Brands Hatch in a single-seater racing car; full details of how to enter are on page 5! Over the coming months there are more exciting competitions to come, but I'm not going to 'spill the beans just yet' – you'll have to wait and find out!

For Subscribers, this month's special offer is a 30% saving on Maxell floppy disks, just look for the loose insert for details. If you're not a subscriber and you don't want to miss out on these regular special offers, take out a subscription! Full details can be found on page 21.

Our cover feature this month is computer viruses; many computer users believe that virus infection only ever happens to 'someone else'. If you have that attitude, you'd better read the feature and find out what the dangers are – when valuable files on disk disappear, or become corrupted, it might just be too late . . .

Finally, there are six great projects and many excellent features, what more could you want from an electronics magazine!

I hope you like the changes, please write in with your comments! So until next month, I hope you enjoy reading this issue as much as the 'team' and I have enjoyed putting it together for you!

ABC
AUDIT BUREAU OF CIRCULATIONS
CONSUMER PRESS

Front cover:
© Copyright 1993
Pictor International Ltd./
Maplin Electronics Plc.
Computer viruses can be likened to their biological cousins – developing immunity to protection methods and becoming more deadly.

EDITORIAL

Editor Robert Ball AMIPRE
Technical Authors Martin Pipe BSc Hons, Mike Holmes
News Compilation Stephen Waddington, Alan Simpson
Technical Illustrators Ross Nisbet, Lesley Foster, Paul Evans, Nicola Hull
Project Development Tony Bricknell, Chris Barlow, Dennis Butcher, Alan Williamson, Nigel Skeels

PRODUCTION

Production Co-ordinator Alan Wraight
Print Co-ordinator John Craddock
Art Director Peter Blackmore
Designer Jim Bowler
Layout Artist Cindy Brown
Published by Maplin Electronics Plc., P.O. Box 3, Rayleigh, Essex SS6 8LR. Tel: (0702) 554155. Fax (0702) 553935.
Lithographic Reproduction by Stirling Graphics Ltd., 16-22 West Street, Southend-on-Sea, Essex SS2 6HJ.
Printed in the United Kingdom by Severn Valley Press, St Ives Plc.

MANAGEMENT

Publications Manager Roy Smith
Development Manager David Goodman
Marketing Manager Vic Sutton
Drawing Office Manager John Dudley

ADVERTISING

Jackson-Rudd & Associates Ltd., 2 Luke Street, London EC2A 4NT. Tel: (071) 613 0717. Fax: (071) 613 1108.
Advertisement Director Colin Pegley
Advertisement Manager James Slater

UK Newstrade Distribution

United Magazine Distribution Ltd., 1 Benwell Road, Holloway, London N7 7AX. Tel: (071) 607 3352.

© Copyright 1993 Maplin Electronics Plc.

Copyright: All material is subject to worldwide copyright protection, and reproduction or imitation in whole or part is expressly forbidden. Permission to reproduce printed circuit board layouts commercially or marketing of kits must be sought from the publisher.

Advertisements: Whilst every reasonable precaution is undertaken to protect the interests of readers by ensuring, as far as possible, that advertisements appearing in the current issue of 'Electronics' are *bona fide*, the publisher and staff of the magazine cannot give any undertakings in respect of statements or claims made by advertisers, whether on printed page or on loose insert. Readers who have reasonable grounds to believe that they have been misled are advised to contact their local Trading Standards Office.

Editorial: The views of individual contributors/authors are not necessarily those of either the publisher or the editor. Where errors occur corrections will be published as soon as possible afterwards.

Publisher's Statement: Maplin Electronics Plc., take all reasonable care to prevent injury, loss or damage of any kind being caused by any matter published in 'Electronics'. Save insofar as prohibited by English law, liability of every kind including negligence is disclaimed as regards any person in respect thereof.

Project Ratings

Projects presented in this issue are rated 1 to 5 for ease or difficulty of construction to help you decide whether the project is within your construction capabilities. The ratings are as follows:

1 Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering iron, side cutters, pliers, wire strippers and screwdriver). Test gear not required and no setting-up needed.

2 Easy to build, but not suitable for absolute beginners. Some test gear (e.g., multimeter) may be required, and may also need setting-up or testing.

3 Average. Some skill in construction or more extensive setting-up required.

4 Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required

5 Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

Ordering Information

Kits, components and products stocked by Maplin can be easily obtained in a number of ways:

Visit your local Maplin store, where you will find a wide range of electronic products. If you do not know where you nearest store is, refer to the advert is this issue or Tel: (0702) 552911. To avoid disappointment when intending to purchase products from a Maplin store, customers are advised to check availability *before* travelling any distance.

Write your order on the form printed in this issue and send it to Maplin Electronics, P.O. Box 3, Rayleigh, Essex, SS6 8LR. Payment can be made using Cheque, Postal Order, or Credit Card.

Telephone your order, call the Maplin Electronics Credit Card Hotline on (0702) 554161.

If you have a personal computer equipped with a MODEM, dial up Maplin's 24-hour on-line database and ordering service, CashTel. CashTel supports 300-, 1200- and 2400-baud MODEMs using CCITT tones. The format is 8 data bits, 1 stop bit, no parity, full duplex with Xon/Xoff handshaking. All existing customers with a Maplin customer number can access the system by simply dialling (0702) 552941. If you do not have a customer number Tel: (0702) 552911 and we will happily issue you with one. Payment can be made by credit card.

If you have a tone dial (DTMF) telephone or a pocket tone dialler, you can access our computer system and place orders directly onto the Maplin computer 24 hours a day by simply dialling (0702) 556751. You will need a Maplin customer number and a personal identification number (PIN) to access the Maplin key call system. If you do not have a customer number or a PIN number Tel: (0702) 552911 and we will happily issue you with both.

Full details of all of the methods of ordering from Maplin can be found in the current Maplin Catalogue.

Prices

Prices of products and services available from Maplin, shown in this issue, include VAT at 17·5% (except items marked *NV* which are rated at 0%) and are valid between 7th May 1993 and 31st August 1993. Prices shown do not include mail order postage and handling charges, which are levied at the current rates indicated on the Order Coupon in this issue.

Technical Enquiries

If you have a technical enquiry relating to Maplin projects, products and components featured in 'Electronics', the Customer Technical Services Department may be able to help. You can obtain help in several ways; over the phone, Tel: (0702) 556001 between 2 p.m. and 4 p.m. Monday to Friday, except public holidays; by sending a facsimile, Fax: (0702) 553935; or by writing to: Customer Technical Services, Maplin Electronics Plc., P.O. Box 3, Rayleigh, Essex SS6 8LR. Don't forget to include a stamped self-addressed envelope if you want a written reply! Customer Technical Services are unable to answer enquiries relating to third-party products or components which are not stocked by Maplin.

'Get You Working' Service

If you get completely stuck with your project and you are unable to get it working, take advantage of the Maplin 'Get You Working' Service. This service is available for all Maplin kits and projects with the exception of: 'Data Files'; projects not built on Maplin ready etched PCBs; projects built with the majority of components not supplied by Maplin; Circuit Maker ideas; Mini Circuits or other similar 'building block' and 'application' circuits. To take advantage of the service, return the complete kit to: Returns Department, Maplin Electronics Plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Enclose a cheque or Postal Order based on the price of the kit as shown in the table below (minimum £17). If the fault is due to any error on our part, the project will be repaired free of charge. If the fault is due to any error on your part, you will be charged the standard servicing cost plus parts.

Kit Retail Price	Standard Servicing Cost
up to £24.99	£17
£25 to £39.99	£24
£40 to £59.99	£30
£60 to £79.99	£40
£80 to £99.99	£50
£100 to £149.99	£60
Over £150	£60 minimum

Readers Letters

We very much regret that the editorial team are unable to answer technical queries of any kind, however, we are very pleased to receive your comments about 'Electronics' and suggestions for projects, features, series, etc. Due to the sheer volume of letters received, we are unfortunately unable to reply to every letter, however, every letter is read – your time and opinion is greatly appreciated. Letters of particular interest and significance may be published at the Editor's discretion. Any correspondence not intended for publication must be clearly marked as such.

Corrigenda

Please note that one of the Figure drawings shown in Issue 64 is in error. In Figure 1 of the 'In-Situ Transistor Tester' on page 17, only pin 9 of IC2 is shown to be connected to 0V. In fact this should show pins 8, 9 and 12 connected to 0V. In addition, because the device is a dual J-K flip-flop type 4027, and only one half is used, pins 3, 4, 5, 6 and 7 should also be connected to 0V. These are the input and control pins of the unused half of the IC, and are pulled low to prevent spurious behaviour of the IC.

TECHNOLOGY WATCH!

with Keith Brindley

Technology Watch this month is basically about developments in the field of high-definition television (HDTV). To date, your standpoint for, or against, high-definition television depended largely upon what side of the Atlantic your feet were planted, although where you were, with respect to the English Channel, also made some difference.

In the United States, for example, there's a race underway to develop what the Yanks would call the 'perfect' high-definition television system: well-designed, state-of-the-art, cheap, and – last but not least (if you're a Yank, that is) – American. They see such a system as being world-beating, with the potential to generate colossal sales by rejuvenating the saturated television market.

In Europe, on the other hand, we had a bit of a race a couple of years ago to show that high-definition television systems were possible – with one contender (HD-MAC) being noted for its intermediate ability to do the job – but little has happened since. Despite this, Europeans see their high-definition television television system as the perfect one. It's well-designed, state-of-the-art, cheap, and – last but not least – European. We see such a system as being world-beating, with the potential to generate colossal sales by rejuvenating the saturated television market. Haven't you heard this all before somewhere?

We could look at similarities between high-definition television systems on both sides of the Atlantic for ever and a day. But where we get the real benefit is by looking at the main *difference*. In the States, companies were invited to suggest alternatives, and the best alternative will be the winning system.

In Europe, though, just about everyone got on the same bandwagon (the HD-MAC one), in the belief that getting the system up and running in the shortest time possible was the optimal solution. It didn't really matter if that system was neither the best one, nor the longest-lasting.

Lacking Definition

Any chance of deciding the fate of any high-definition television system in Europe looks set to be scuppered in May, by the UK Government. I'm not an ardent admirer of our Government (in fact, I've been known to slag it off on occasion) but this time I do feel they've about got it right – just for the wrong reasons, that's all. To see why, you've got to look at the history of European attempts to generate a high-definition television system, and come to grips with what's gone on around the world.

Prospects of having some form of better television system than the current PAL system were first mooted when satellite television systems were in their infancy. Satellites, with their potentially wide bandwidths, seemed the obvious method of introducing a new system which, due to its very nature, requires greater bandwidth than PAL (as the old saying goes, you can't squeeze a quart into a pint pot). Way back then, no-one was arguing against the belief that, at some time in the future, PAL was going to have to be replaced by a better system. Indeed, the only question being asked then was *when would the technology be available*?

Satellite systems came and went. PAL services started up on telecommunications satellites; a new system – MAC (*multiplexed analogue component*) was devised, which promised (and, for that matter, delivered) higher quality pictures (in its basic form, not *high*-definition television, mind you); British Satellite Broadcasting planned the ill-fated Marcopolo satellite (the subject of current debate in 'Electronics'), using MAC transmission – but then along came Astra.

From the outset, most services from Astra were in PAL. Not that other formats can't be used – the odd channel uses MAC. This overall use of PAL, while seemingly a retrograde step (I mean, why use PAL when MAC delivers better pictures and sound?), proved to be the big turning point in the charge towards high-definition television.

Previously, high-definition television was the dream of the television manufacturer. Broadcasters weren't so sure it was what people wanted. The people themselves didn't even know what HDTV was, and couldn't see what all the fuss was about. The then Sky Television gauged the market right, though. Bringing out a system broadcasting in a MAC format would mean more expense, which people might not be prepared to pay. PAL was almost certainly good enough for the vast majority.

This marketing angle proved to be correct. Many people bought Astra systems, while a relatively small number bought BSB systems. Now, Astra has viewers in their millions, while BSB is defunct. As a brief aside, many BSB receivers live on, having been converted to receive MAC transmissions from the Continent (these are almost exclusively broadcast in D2MAC, while BSB used the DMAC system).

Yet *still* the manufacturers push towards high-definition television. The latest idea is to use HD-MAC, a 'souped-up' version of basic MAC, to give a sort of 'stepping-stone' system with better quality pictures and sound (but not quite true *high*-definition) until a new digital system comes along.

Television manufacturers have their interests at heart, of course. If a new system is created, everyone with an existing PAL television receiver would eventually (say, within ten years) buy a new high-definition television receiver. So the potential sales earnings is colossal. Better still, if the system you create now is only a stepping-stone, you can create an even newer, better, digital system in another 10 years, which will generate even more sales, of digital television receivers.

On May 10th, ministers from EC countries are meeting to decide European plans for high-definition television. There are several alternatives – we could use HD-MAC, an upgraded PAL system (PAL-Plus), the American system (as yet undecided), or we could wait for a decent digital system. Alternatively, we could do nothing.

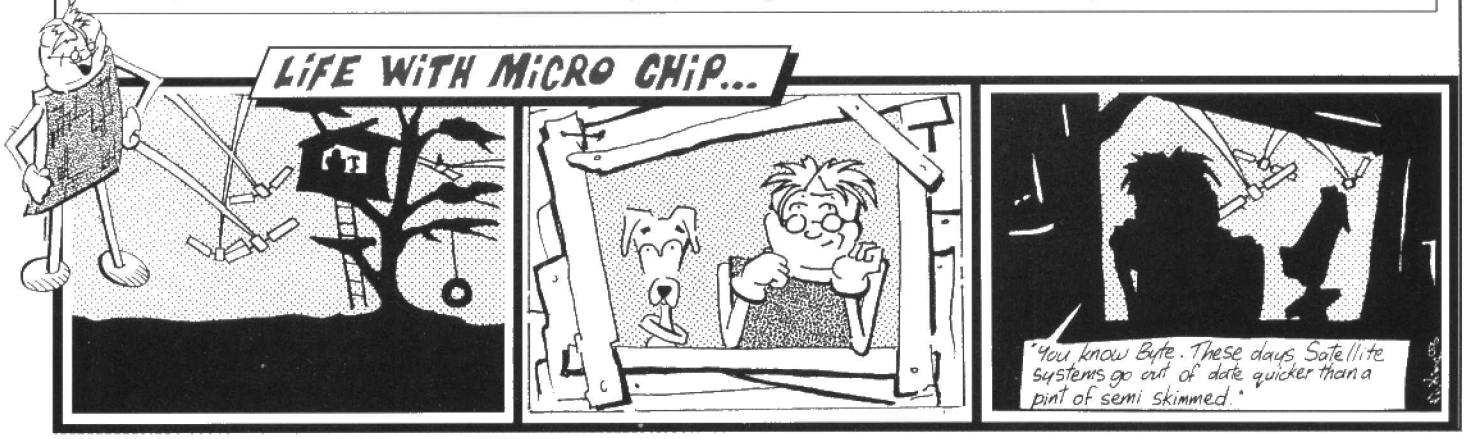
Whatever we do, the UK Government is right to halt progress to a MAC high-definition television system. It is not needed, neither is it wanted by the user. (Anyway, why run before you can walk. UK broadcasters – satellite and terrestrial – should ensure that all viewers can receive *decent* quality PAL pictures first; in practice, the poor picture quality perceived by many viewers is not due to limitations of the PAL system itself! – Ed). Let's wait until a half-decent digital system is devised, which can see us forward for the next half-century or so, without being a half-cocked attempt just to earn the manufacturers a bit more cash.

Whether the UK Government's grounds for doing this are as proper as the morals I've suggested here are a bit more debatable. It's more likely that the Government's main argument against it will be in terms of where the development money is going to come from, rather than which system should be used. Should, for instance, the manufacturers themselves be made to pay for development, rather than letting public money be injected into it? We're talking big money here – 500 million ECUs. But that's another question. Quite simply, high-definition television is no nearer being introduced than it was ten years ago. Any further delays to the development will probably rule out HD-MAC, since digital systems are already in the pipeline.

Phone Home and See Mum

BT has just started to sell its videophone. If you have one, and your respondent has one, you can see each other in tiny colour LCD screens located in a flip-up panel on the telephone unit. This has been a long time coming for several reasons, none of which I'll bother to go into here because they're not particularly relevant. I first saw a prototype at GEC-Marconi a year or so back, and have to admit to being quietly impressed. It's nice, and I can see a great future for it (pun intended).

Interestingly, the phone uses analogue technology rather than going for a high-fallutin' digital version. In many respects this is the telephone itdentikit match of the high-definition television problem just highlighted. Why go for an expensive digital system just yet? Existing analogue technology is good enough for a few years yet, but no-one's denying that digital is – ultimately – better. It's just not needed by the user yet, so is simply unnecessary at this time.



NEWS XTRA

'ELECTRONICS' EXCLUSIVE!

THE SPIRIT OF LONDON – Bringing the Waxworks to Life at MADAME TUSSAUD'S

Early May 1993 sees the opening of the spectacular new six-minute "Spirit of London" ride at Madame Tussaud's, London. The most ambitious project ever to be launched by a visitor attraction in London, the £10 million dark ride finale is the culmination of a five year, £21 million transformation scheme at Madame Tussaud's. For the first time, audio-animatronics – moving, speaking figures – will be featured alongside the wax figures for which the venue is world-renowned. The ride, which occupies the same area as two side-by-side football pitches, will include the very latest in special effects, and will recreate the sights, sounds, and even the smells, of some of the greatest events that have shaped London's rich heritage.

Visitors will experience such historical milestones as the Great Fire, the building of St Paul's Cathedral, and the Blitz. The ride also features Queen Victoria taking a hands-on role in the industrial revolution, Shakespeare writing one of his great works, a bird's eye view of the firework celebrations for the opening of Trafalgar Square, and ends with a trip down memory lane to the swinging Sixties. Other key characters include Sir Christopher Wren, Winston Churchill, Charles Dickens – and even Twiggy!

"The Spirit of London has taken three years to build," comments Tony Greenwood, Senior Design Engineer with The Tussaud's Group Studios. "It's the most technologically advanced development ever at Madame Tussaud's, and visitors will participate in 400 years of London's history. We decided to use animated models as part of the show, right from the start of the project." There are 36 animated figures used in "The Spirit of London", together with 43 wax dummies.

He continues: "The Tussaud's Group design studio developed the concept of the ride, starting with a storyboard, and then moving on to a scale model. From the list of figures to be built, the engineering department prepared details of animation capabilities. Using the AutoCAD design software running on Compaq 386-based PCs, we started with the basic figure – although we designed into it the maximum amount of animation required – and from this we developed all the other figures, some of which were a little less animated, or only required certain movements or functions to be incorporated. There was a fair amount of animation work, and we designed the figures to incorporate pneumatic equipment. Using the pneumatic component manufacturer's expert system as an application within AutoCAD, we were able to quickly and easily work out which parts we needed, and incorporate them directly into our designs."

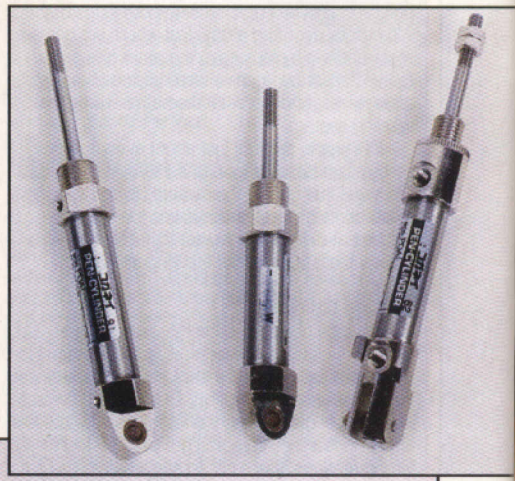
Pneumatic Panorama

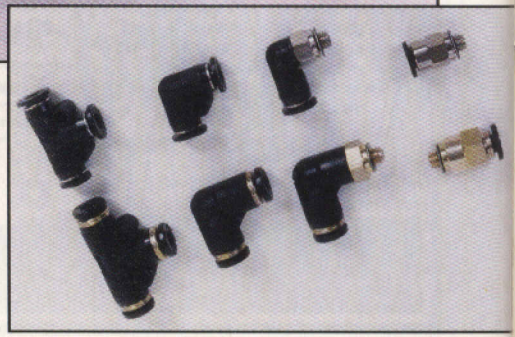
The systems used to animate the figures are made by Kosma Pneumatic Products – a partnership in technology between Koganei of Japan and Drallim Industries, and a company which has extensive experience in the factory, electronics and automotive automation markets. "We feel we are at the forefront of technology in assisting UK companies to create products for the world's industries", says Stephen Spencer, Kosma's Technical Manager. He goes on; "It is Madame Tussaud's policy to maintain its accurate portrayal of characters, whilst developing the use of technology." This policy includes a long-term commitment to the animation of some figures by means of pneumatics.

The development of a good working relationship between Madame Tussaud's and Kosma was established very quickly and specialised cylinders (pneumatic actuators with a linear motion) were developed, with specific characteristics for use within the head of the animatronic figure to control the facial features. Traditionally, the use of pneumatics within this type of environment has presented considerable problems to engineers, and so Kosma approached the project with two clear-cut objectives. The first of these is to enable pressure and speed control to be as effective as possible, while the second is to use low 'stiction' movement devices such as cylinders.

For most visitors to Madame Tussaud's, wax figures are a startling three-dimensional likeness of all manner of people who are known by face or repute, and can be either adored – or, sometimes, abhorred. When a

Left: The Spirit of London – as captured by Madame Tussaud's.
Below: Behind the scenes – Kosma pneumatic components; cylinders, solenoid valves and fittings.





Twiggy – and all things psychedelic!

figure enters Madame Tussaud's, the studios remain closely concerned with its appearance, and, like every other figure, each day it undergoes an early morning routine of checking and cleaning before the exhibition opens. This rigorous attention to detail is constantly maintained, and continues to uphold the unsurpassed high standards for which Madame Tussaud's is justifiably famed. The animated figures are even more extraordinary – and, face-to-face, they transform apparently into flesh.

Design Considerations

The prime consideration towards fitting pneumatic equipment into the animatronic figures was one of space-saving. In some cases, extremely short strokes of only five millimetres were needed to bring a face realistically to life.

"In an animated figure – especially those of the complexity of some at Madame Tussaud's – it is essential that individual operations are controlled by varying pressures to the system," reveals Spencer. "Kosma are striving to achieve new levels of technology in applications where pneumatics has not previously been considered – and it has a total commitment to pneumatics, with cylinders ranging from 2·5mm to 200mm in diameter." Normal pneumatic technology will not allow control down to five millimetres of movement, and so Kosma offered solenoid-operated valves – a new concept – to Tussaud's Group engineers.

"These give exceedingly high flow capabilities by the use of indirect-acting valves, and at extremely low pressures. And, in order to make the system even more compact, purpose-built manifolds were developed by the Tussaud's Group Studios to house the range of solenoid valves and pressure regulators in a combined unit. The engineers could now incorporate far more complex mechanical and pneumatic movements in the same space where they had previously been extremely restricted."

"Once we'd decided on each figure's capabilities, we had to split them into their component parts," observes Tony Greenwood. "We were aiming for repeatability and ease of use in construction and design. And, without the ease of use of a CAD system, it is obvious that there is no way we could have completed such a multi-million pound project on time." To have designed and produced 36 animated figures within the space of a year is, by any standards, a terrific achievement!

In forthcoming issues of 'Electronics', Stephen Spencer will explain the practical and theoretical aspects of modern pneumatic control systems. Stephen's guide shows how pneumatics can be used to control anything from small home-made models to large industrial processes.

COMPETITION

G-G-Go R-R-Racing at Brands Hatch!

In this issue's super competition there's the chance to fulfil that driving ambition – to sit behind the wheel of a high performance single seater racing car, and drive it around the world famous Formula One circuit, Brands Hatch! Winners can *choose* from Oulton Park in Cheshire or Snetterton in Norfolk, instead of Brands Hatch in Kent, if they so prefer.

Here's the itinerary for the two lucky winners:

Your course starts with a video briefing and question session, after which you will be fitted out with a crash helmet prior to being introduced to your personal instructor. A driving analysis and personal instruction session follows in a sports saloon after which your instructor takes you for a high speed ride – just to show you how it's really done! Then the moment you've really been waiting for – your chance to drive a high performance single-seater racing car around the race track for a number of exhilarating, adrenaline pumping, high speed solo laps!

Finally, you will be presented with a colourful commemorative certificate as a reminder of the day you first drove a racing car!

You can bring along family and friends; they can wander down to the pits, take photos, and watch you fulfil your driving ambition!

For the four runners up, there's super colour books on the world of Formula One to be won!

All you have to do to enter the competition to win one of these super prizes is correctly answer the four questions below, write your answers on the cover-mounted entry card, fill in your name, address and daytime telephone number and post your entry. Your entry must reach us by 30th June 1993.

The first two correctly answered entries drawn after the closing date will have the opportunity to G-G-Go R-R-Racing! The next four correctly answered entries drawn will receive the runners up prizes of books on Formula One Racing.

If the cover mounted entry card is missing, you can still enter by sending your answers on a postcard (or sealed envelope) to: Go Racing Competition, The Editor, Electronics Magazine, P.O. Box 3, Rayleigh, Essex, SS6 8LR.

Please Note: The first two prize winners must be over 18 years of age and hold a current full UK driving licence. No cash alternative will be offered. Employees of Maplin Electronics and their families are not eligible to enter the competition.

1) Who was the 1992 Formula One World Champion:

a) Nigel Lawson
b) Nigel Kennedy
c) Nigel Mansell
d) Nelson Piquet

2) What is the USA's equivalent to Formula One motor racing:

a) Formula USA
b) Indy 500
c) Drag Racing
d) Formula Indy

3) Which commentator has a reputation for being a 'master of understatement':

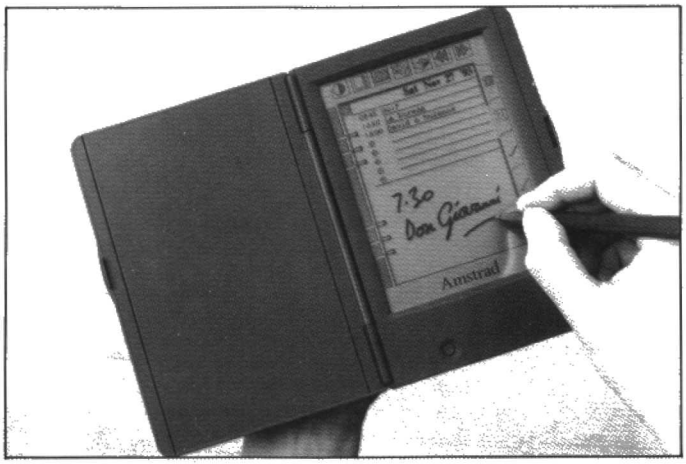
a) David Coleman
b) Murray Walker
c) Dickie Davies
d) Desmond Lynham

4) Which European city's roads are used as a Formula One race-track:

a) Madrid
b) Monaco
c) Marseilles
d) Manchester

NEWS Report

Amstrad Gets Organised



Last month saw the long-awaited launch by Amstrad of its Personal Digital Assistant (PDA). Known as the Pen Pad, the device is a slim, pocket-sized (if you've got a large pocket) personal organiser. The Pen Pad instantly recognises handwriting and turns it into text for storage, transfer, fax transmission or printout and is fully multi-lingual; the owner merely selects the desired language when first switching on. Directed at the traditional loose-leaf (and more recent electronic organiser) markets, the Pen Pad uses a simple 'pen' for all input, doing away with the need for a keyboard. With a price tag of £299.99 including VAT, the unit makes use of three 8-bit processors – one is dedicated to the handwriting recognition, the second to the screen display, and the third to general processing. Amstrad is expecting to sell some 200,000 units over the next couple of years – we wonder how many of these will be used to input data into larger PCs. The end of the keyboard looms closer!

Minitel Bound Ahead

Revenues from France Telecom's Teletel viewdata system just keep on growing. Last year saw a traffic growth of 10% – equivalent to some 2,000 calls. At the same time, the number of Minitel terminals installed grew by 5% to a total of 6·3 million. It seems that, out of five Teletel calls, one is orientated toward games or messaging, but the remaining four, evenly split between home and business users, are used to access information services. In order to meet complaints of the slow speed, a new 'Teletel Vitesse Rapide' service will operate at 9,600bps – double the existing rate. We bet that BT are still kicking themselves for turning their back on the electronic directory!

Safety First

Perhaps surprising for a government prone to accidents, the DTI has switched on to electrical safety. The Department is promoting the use of 'whole house' and 'socket' residual current devices (RCD), which automatically disconnect the power if there is a fault in the electrical appliance or the wiring. The initiative aims to inform people that an RCD will reduce the risk of injury from electric shock or fires caused by electrical faults. Every year, says the DTI, thousands of people are injured by faulty electrical goods, but many of these could be avoided with a little more care.

Octal Power IC

The TPIC2802 octal power integrated circuit from Texas Instruments contains eight low-side drivers, and offers the designer considerable advantages in terms of ease of use, reliability and improved inductive load switching.

Configured as a Darlington stage, each of the TPIC2802's eight outputs requires minimal on-state drive current; approximately 50mA, which represents an 80% reduction over equivalent designs. As well as bringing considerable advantages in reliability, this significantly simplifies the design of the power supply circuitry. The power consumption can be further improved by using the device in 'standby' mode, giving a continuous rating of only 20mW.

The device is capable of sinking 1A simultaneously from each of its limited outputs. Each output has 45V transient clamping and a 2mJ rating, making the device particularly well suited to demanding automotive and industrial inductive switching applications.

The TPIC2802 contains an 8-bit serial-in parallel-out shift register that feeds directly to an 8-bit parallel latch, thus allowing independent control of each output. Data is entered serially via the serial input and is fed directly to the lowest bit of the shift register. Data may be clocked in at a maximum frequency of 1MHz for single device operation, or 630kHz for cascaded operation. Contact Texas Instruments on (0234) 223 252.

Monitoring the Office Environment

A British company, Winton Environmental Services, has launched the world's first continuous air monitoring device designed specifically for offices – the Monitair 393. The launch is in response to growing concern about the quality of air in offices and new legislation that came into effect at the beginning of this year, making employers responsible for the monitoring and control of office conditions. The Monitair 393 provides a simple, cost effective solution to help companies comply with the legislation and also reassure their employees that standards of air quality are being monitored and maintained.

The Management of Health & Safety Regulations 1992 require employers to assess the risk that their employees face, and to implement procedures for the planning, organisation, monitoring and review of both preventative and protective measures. The new Regulations cover a variety of potential hazards, of which poor air quality is generally regarded as one of the most significant.

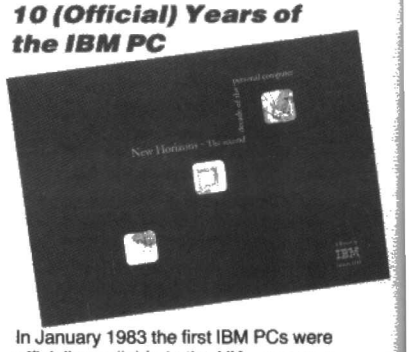
Airborne hazards in offices range from gases such as carbon dioxide, ozone, sulphur dioxide and formaldehyde to micro-biological contaminants such as bacteria and fungi, and inhalable airborne dust particles, especially those that are respirable deep into the lungs. Air conditioning systems, carpets, photocopiers and laser printers are all potential sources of these hazards. Although it is difficult to establish a direct link between particular contaminants and specific health conditions (particularly allergies), current research suggests that the cumulative effect of such factors is largely responsible for the ailments associated with a 'sick building'.

The Monitair 393 represents the culmination of 20 years of experience gained by Winton Environmental Services in the UK and around the world. The wall mounted box is a continuous, time-weighted air sampler, designed to record the presence of any airborne particles or gases over a given time. Acting as an early warning device, the Monitair 392 enables prompt identification, by Winton's technicians, of higher than normal levels of airborne contamination. Once the specific problem has been identified, Winton is able to advise clients – who already include many international companies – on the correct and most cost-effective course of action. Contact Winton (081) 337 0731.

But Will They Play Mike Oldfield?

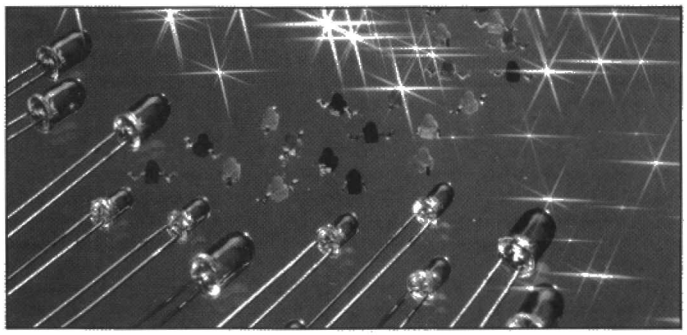
Meanwhile, on Friday 30th April, the first national commercial rock station to be launched in Britain, Virgin Radio 1215, goes on air at 12.15pm. Broadcasting quality rock music 24 hours a day the station's guiding principle will be 'much more music – with intelligent and informative comment, and no DJ chatter'. Virgin Radio's output will encompass all the classic tracks of the past 25 years, and the station will also be broadcasting a weekly chart show that concentrates on the best-selling albums, rather than singles. Whether the discerning listener, at which Virgin is aimed, will tolerate the poor sound quality of MW/AM, and all the pops and whistles that go with it, remains to be seen (heard?), but the programming seems well worth a listen. Perhaps Virgin might follow the BBC's lead (more on this later) and consider an additional service, distributed via Astra satellite radio, at a later stage, but for the time being the new broadcaster can be found on 1215kHz on the MW band.

10 (Official) Years of the IBM PC



In January 1983 the first IBM PCs were officially available in the UK – yes, you could buy them before that, but they were grey imports sold at inflated prices by the dealers in question. In the 10 years that followed, the PC has now become an industry-standard, and a business necessity; in fact, even IBM were overwhelmed by the response of the marketplace. To reflect over 10 years of PC success, IBM have produced a brochure, 'New Horizons – The second decade of the personal computer', which looks back at how the PC has changed our working lives, before looking forward to what the future holds in store. A copy of this brochure is available, free of charge, to 'Electronics' readers; those interested should call Neil Hope on (081) 995 7700.

Brighter AlGaAs LEDs

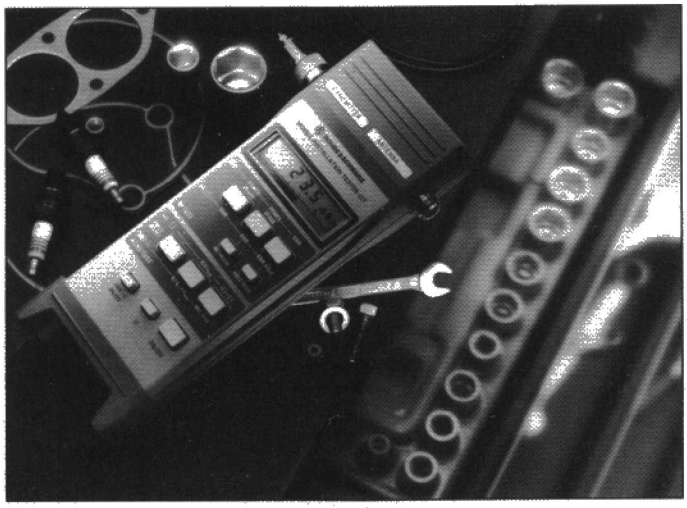


LEDs are fine for panel applications, provided that ambient light conditions are low. Brighter illumination requires miniature incandescent lamps and consequently a ten-fold increase in power, resulting in a reduction in electrical efficiency. Such lamps are also notorious for their limited lifespans.

Quality Technologies Corporation have been considering the problem for a while and, after mixing an elaborate cocktail of semiconductors, have now launched a series of super-bright AlGaAs LEDs.

Encapsulated in epoxy packages, the 5mm LEDs (in either red or green) have a clear lens, and offer a high light output over a wide range of drive currents. Typical luminous intensities vary between 300 and 1000mcd at 20mA, for the green and red devices respectively. Contact Quality Technologies on (0892) 511 871.

A Testing Time



Cellular users, in particular, should be grateful to Rohde & Schwarz for introducing a new range of test equipment designed for the GSM generation of mobile cellular phones. The all-new CIT is a small, lightweight, hand-held tester which has all the functions necessary for ensuring correct installation and rapid fault-finding in any mobile phone system that operates on frequencies of up to 1000MHz. Thanks to its frequency coverage of between 100MHz and 1000MHz, the CIT is suitable for carrying out measurements on analogue and digital cellphones in compliance with all relevant standards, including GSM, ETACS, NMT, Network C and AMPS. The tester measures power, standing wave ratio (SWR), current and voltage. In addition, a continuity tester and microphone tester are incorporated.

Single Electron Memory

Japanese and British scientists at the Cavendish Laboratory, Cambridge, have claimed a major breakthrough in the development of the single electron memory in which one bit of data is stored using a single electron.

A paper published in the recent edition of the Institute of Electrical Engineer's Letters describes how the principle of controlling single electrons can be applied to semiconductor memories. Instead of requiring around half a million electrons per unit cell, single electrons could be controlled individually, with a precise number of them present in each memory cell.

Polaroid Have a Vision

Due to be vigorously promoted, if it isn't already, is the new Polaroid Vision camera, which has been under development since 1987. Gone is the 'bulky box' image – which has dogged Polaroid's famous instant cameras of the past – to be replaced by a smart new computer-controlled unit that bears more than a passing resemblance to the 35mm compact cameras that currently dominate the market, at least when it is folded up. The Vision is described by Polaroid as offering the 'convenience of a single-lens-reflex (SLR) with the ease of use of a 35mm compact, and all the advantages of an instant picture camera'. And these factors would seem to make it a winner, at least if the camera's success in Germany is anything to go by – there, according to Polaroid, sales are running at double the original expectations.

At the heart of the Vision is a microcontroller, which replaces 7 ICs used in previous designs, while providing 'intelligence'. This controls exposure times, the autofocus system, the flash, film processing and battery output. The power for the camera is derived, as with previous Polaroid designs, from a battery contained within the film cartridge. The optical system is true SLR – yes, to use computer terminology, WYSIWYG (What You See – through the viewfinder – Is What You Get). This puts it at a considerable advantage when compared to 35mm compacts; coupled with the fact that you can see the photos developing after taking them, this feature makes the Vision ideal for those 'once in a lifetime' snaps – never will you have to suffer the well-known disappointment of photographs that 'haven't come out properly', or have been 'lost by the developer'. The Vision's a lot cheaper than a camcorder (with playback through the viewfinder) as well! To counter criticism of previous designs, Polaroid have incorporated a unique storage and viewing chamber at the back of the camera, which can store up to 10 photos. Through a window, you can watch your photos take form without exposing them to the outside elements, or you can take the next shot while the last one is developing.

The image quality of Polaroid photographs has always been questioned by experts. But, for use with the Vision, Polaroid have developed (no pun intended!) the new 23-layer Vision 95 film, which has an ISO speed rating of 600, allowing the use of a relatively fast shutter speed and small aperture, for the 'best possible picture quality'. According to Polaroid, Vision 95 is 'one of the most chemically complex products made for any purpose, not just photography'.

At £89.99 (due to rise to £99.99 in June), the Polaroid Vision appears to offer excellent value for money. However, no mention is made in the press release as to how much the film costs!

Remote Reading

Schlumberger and Motorola have formed a joint venture to develop wireless electronics technology for remote and automated meter reading. The aim is to provide integrated solutions for water, gas and electricity utility meters on a global basis. BT is promoting the concept of ISDN (Integrated Services Digital Network) to the service providers; the ISDN network, say BT, would be ideal for interrogating meters remotely.

Cable Surfaces

The UK cable market is expected to grow by over 60% during 1993, according to the Cable Television Association. Currently the number of subscribers exceeds 450,000 – the total is expected to reach a somewhat optimistic 700,000 by the end of the year. At the same time, the number of telephone exchange lines operated by cable companies now stands at a total of 126,700, of which 110,000 are residential lines.

Events Listings

Now Open: 'Flight' Aeronautics Gallery, and 'The Secret Life of the Fax Machine'. Science Museum, London. Tel: (071) 938 8000.

15 to 16 May. Model Exhibition and Display, Sandown Park, Warwickshire. Tel: (0608) 662212.

20 to 23 May. Spring Computer Shopper Show, National Hall, Olympia, London (Save Money! £1·50 off the entrance fee, when you take along the voucher printed on this page). Tel: (081) 742 2828.

22 May. All-Format Computer Fair, Sandown Park, Warwickshire. Tel: (0608) 662212.

Till 20 June. SuperBike. An exhibition of the Olympic gold medal bicycle. Science Museum, London. Tel: (071) 938 8000.

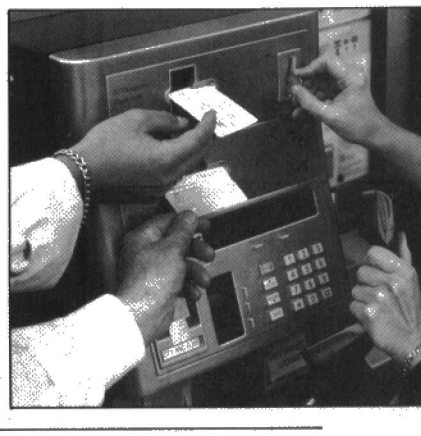
Please send details of events for inclusion in 'Diary Dates' to: The Editor, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex SS6 8LR.

PICTURE CAPTION CHALLENGE

No, it's not 'many hands make light work' in this month's 'what is it?' contest. No prizes, but just what is happening?

★ The mad rush for Greater London community radio broadcasting FM licences is on!
★ Sabotage! The Mercury engineers seen here are keen to screw up BT's record for having the greatest number of 'in-use' public call boxes!
★ Pay-phone longevity testing.
★ "Yes – another bl**dy signal failure at Laindon. Can I have a taxi, please?"

Well, no. Actually it is BT demonstrating the payment flexibility of its new 'four-in-one' public payphones, which are currently on trial.



£1.50 OFF ON THE DAY!

COMPUTER SHOPPER Show

SPRING 20 23 MAY 1993

National Hall
Olympia
London

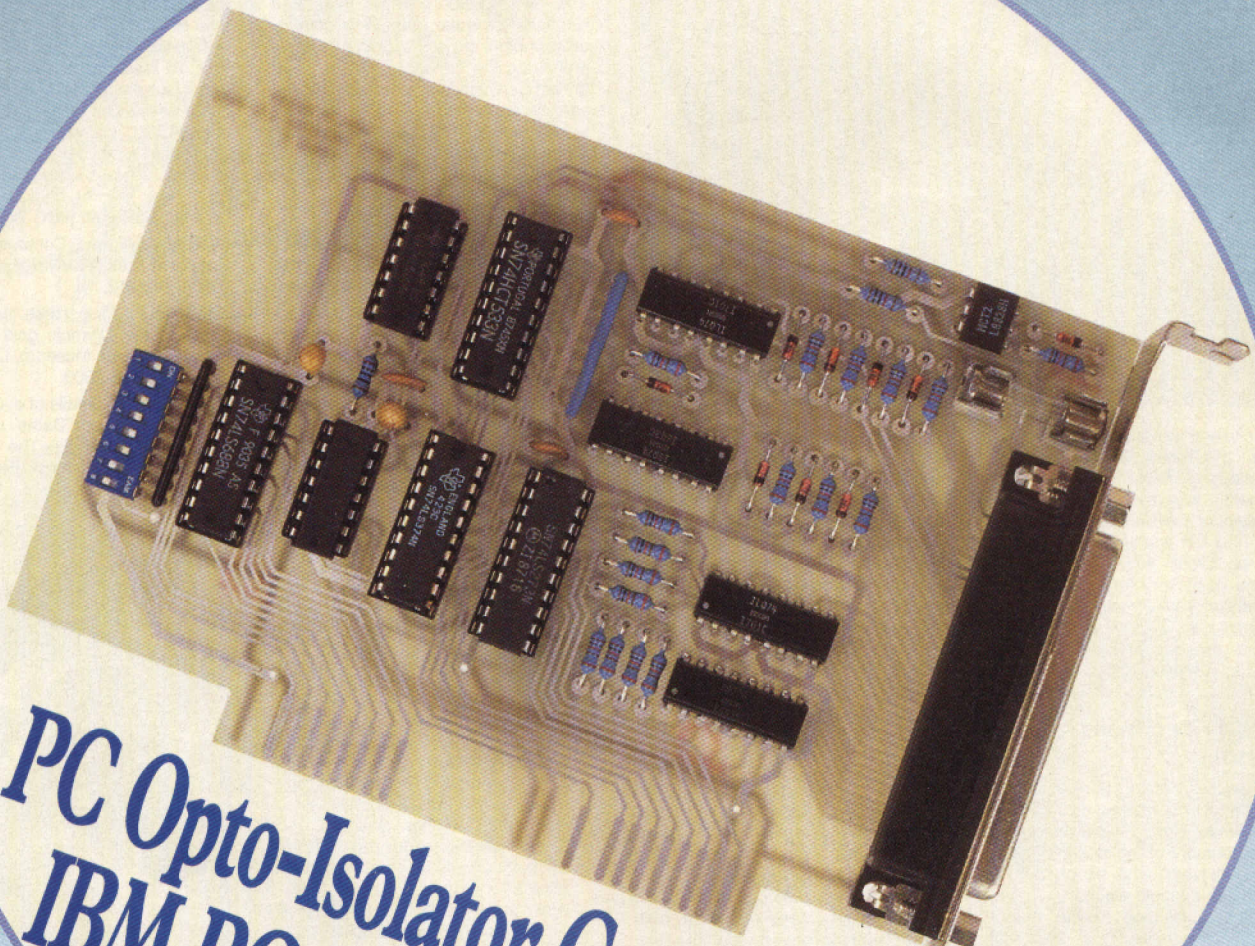
BLENHEIM

Sponsored by Computer Shopper Magazine

Show opening times

Thursday 20 - Saturday 22 May	10am - 6pm
Sunday 23 May	10am - 5pm

Only one voucher per person. Photocopies not valid. Valid on entry to show only.



PC Opto-Isolator Card for the IBM PC and Compatibles

Design by Tony Bricknell
Text by Tony Bricknell and Mike Holmes

2 PROJECT RATING

FEATURES

- *For use with IBM PC, PC-XT, PC-AT and compatible clones*
- *100% galvanic isolation*
- *Eight 'double buffered', optoisolated inputs with strobe*
- *Eight optoisolated transistor switch outputs*
- *High isolation voltage*
- *Fused 5V output to power external circuits*
- *Selectable base address*

APPLICATIONS

- *Isolated data links* * *Connection of switches, tachos, pulse devices and detectors* * *Robotics*
- *Process control* * *Timer control* * *Home automation*
- *Control of lamps, motors, solenoids*

This project is a versatile interface card for use with the IBM PC, PC-XT, PC-AT and compatible clones, featuring electrical isolation of both inputs and outputs using the optocoupling technique. There are separate, 8-bit parallel input and output connections on the card, with an additional strobe input being provided for the 8-bit parallel input. This strobe can be disabled if required, improving the flexibility of the card. The strobe function will be discussed in more detail later.

The card slots into any one of the vacant expansion slots provided on the host PC, and the power, control, address and data signals are obtained from the computer's expansion bus. The optoisolated inputs and outputs are brought out to a rear panel mounted, 37-way, female D-range connector, together with a fuse-protected +5V supply, allowing easy connection with the outside world.

The card uses discrete logic, as opposed to a fully programmable input/output IC, and therefore has the advantage that it does

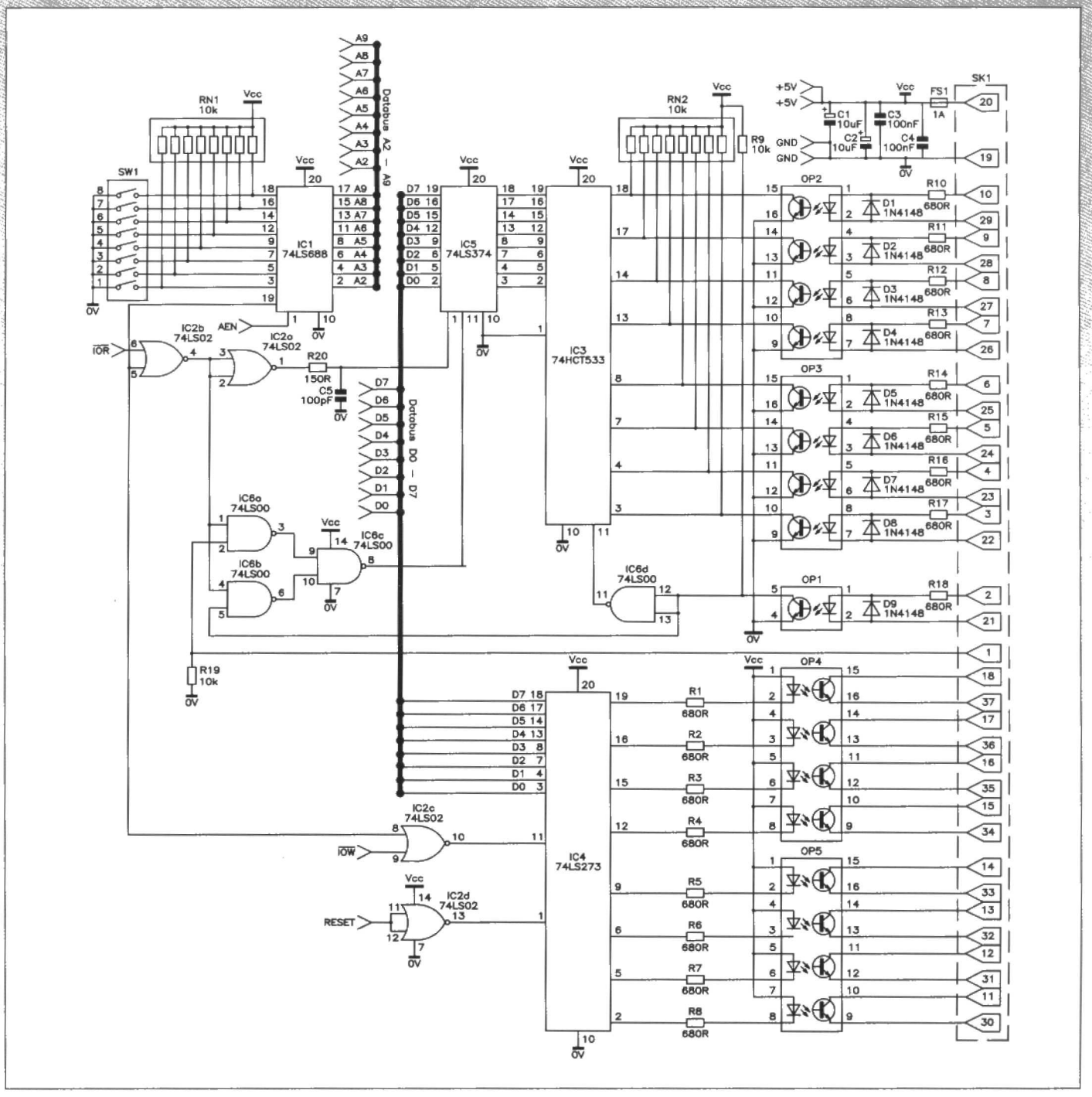


Figure 1. Circuit diagram.

not need to be configured or initialised before use. Data can simply be written and read to, and from, the appropriate address.

Circuit Description

Figure 1 shows the circuit diagram of the PC Opto-Isolator Card, and the following circuit description should help the constructor understand operation of the unit and assist in fault-finding, should this become necessary.

Any 'initialisation' of the card is restricted to the moment when the computer is first powered-up, whereupon a RESET pulse is placed on the computer's control bus. This is inverted by one gate of a 74LS02, IC2d, which then transfers it to pin 1, the 'clear' input, of IC4, an octal D-type flip-flop, resetting its outputs to zero, thereby ensuring that all eight transistors of optoisolators OP4 and OP5 are ON.

Actual reading and writing is performed as follows. IC1 is an eight-bit comparator and, if the data pattern on the address bus A2 to A9 matches that set by DIL switch bank SW1, via lines pulled up by SIL resistor array RN1, then pin 19 will go low. This activity is accompanied by the host computer requesting either a read or write from the card by pulling either IOR or IOW low, respectively.

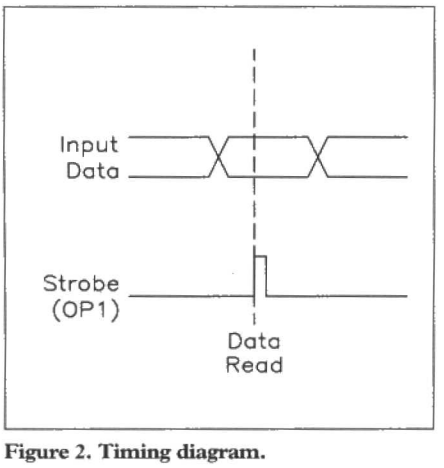


Figure 2. Timing diagram.

If both the address enable line at pin 8 and IOW at pin 9 of IC2c (a NOR gate) are low, then a positive write pulse is generated for input pin 11 of IC4. This causes the information on the data bus lines D0 to D7 to be simultaneously loaded into and held by the octal latch IC4, and transferred to outputs Q0 to Q7. The binary logic states of this data determine which LEDs, and therefore which transistors, in quad optoisolator packages OP4 and OP5, are ON (logic low = LED and transistor ON, logic high = LED and transistor OFF). If the transistors were operated in grounded emitter mode with collector loads to an external supply, then the collector logic levels would exactly reflect those of the host computer's data bus, but with complete electrical isolation. In addition, the last value to be output will

be retained in IC4 until changed by writing a new value.

Alternatively, if the address is matched and IOR is low, then 8-bit input data can be read. IC5 is another octal D-type latch with tristate outputs. The coincidence of the address enable line from pin 19 of IC1 and IOR is detected by NOR gate IC2b, and passed via inverter IC2a to pin 1 of IC5, the Output Enable control, placing the data latched in this device onto the computer's data bus. A small amount of delay is introduced along the way by R20 and C5; more about this in a minute.

Data input is applied to optoisolators OP2 and OP3 via resistors R10 to R17, which limit the input current to around 4mA for the optocoupler LEDs. These values are suitable for an external driving voltage level of 5V; if other voltage values are used then the values must be altered to suit. Reversed polarity protection is provided by clamping diodes D1 to D8.

SIL resistor array RN2 provides anode loads for the output transistors of OP2 and OP3. These connect directly to the inputs of an octal, inverting D-type latch with tristate outputs, IC3. A CMOS version is used here to present minimum loading to the optoisolator devices. IC3 forms the first part of the 'double-buffering' method employed in this design, the second part being IC5, for the reasons given as follows.

Strobing

In normal circumstances, the data coming from optoisolators OP2 and OP3 needs to be clocked into IC3, that is, loaded into the IC's latches under controlled conditions using its Latch Enable pin, pin 11. This is a very common technique and involves presenting the data to the inputs and then, when it is stable, applying a control signal (commonly known as a strobe signal) via optoisolator OP1 and inverter IC6d. This causes the 8-bit data to be recognised and latched on the positive leading edge of this pulse. A timing diagram which illustrates this is shown in Figure 2. Simultaneously, the active low element of this pulse is delivered to one input of IC6b.

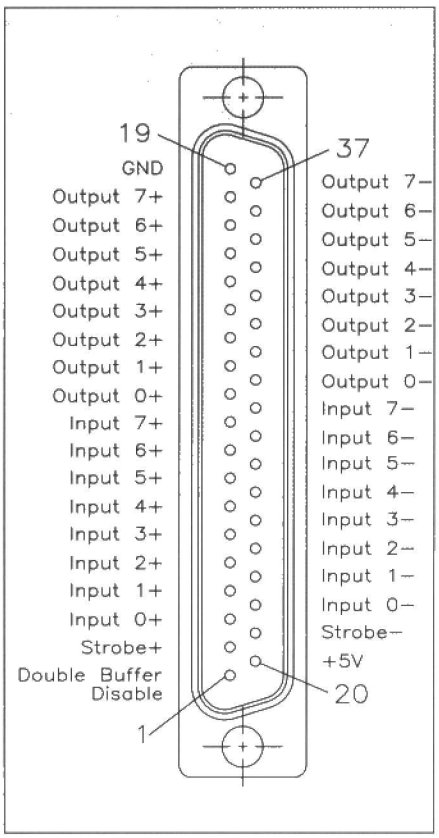


Figure 3. 37-Way D-range connector pinouts.

IC6a, b and c form a control block which will transfer data from IC3 to IC5 when the host computer requests a read, but only if the strobe pulse to IC3 is not active high at that moment. This is what is meant by 'double-buffering', and it ensures that, if the computer sends a read request to the card whilst external data is being strobed into the card, the data will not be read incorrectly by the computer. This is the function of the active low 'hold-off' line between OP1 and IC6b pin 5. In the event that the strobe input is active, only the data last latched into IC5 will be read.

Otherwise IC6c is allowed to operate the 'clock' pin of IC5, by virtue of the fact that the combined address select and IOR signal from IC2b is able to carry through to IC6c while the 'hold-off' line (IC6b pin 5) is high (strobe not active). The data contained in IC3 is transferred to IC5, and simultaneously appears, via the enabled outputs of IC5, on the data bus, as described earlier.

The double-buffering can be disabled by making pin 1 of PL1 high by linking it to pin 20 of PL1. This causes IC6c to always respond to the address, and IOR gating signal from IC2b, regardless of the state of the strobe input, such that when the computer issues a read request, the data returned is that actually on the port inputs at that split second. Note that if this new data is being strobed into OP2 and OP3 at the same moment when the

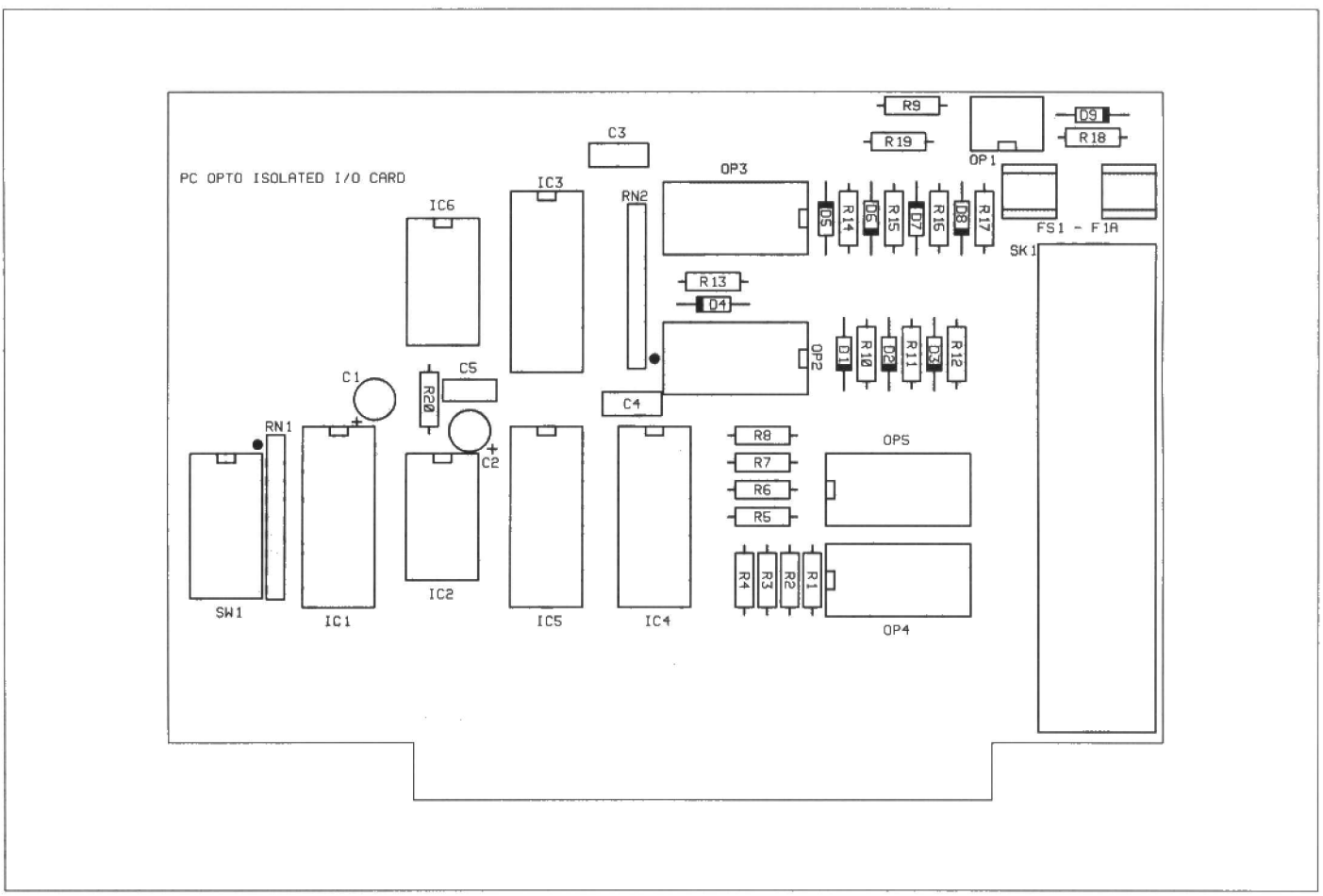


Figure 4. PCB legend.

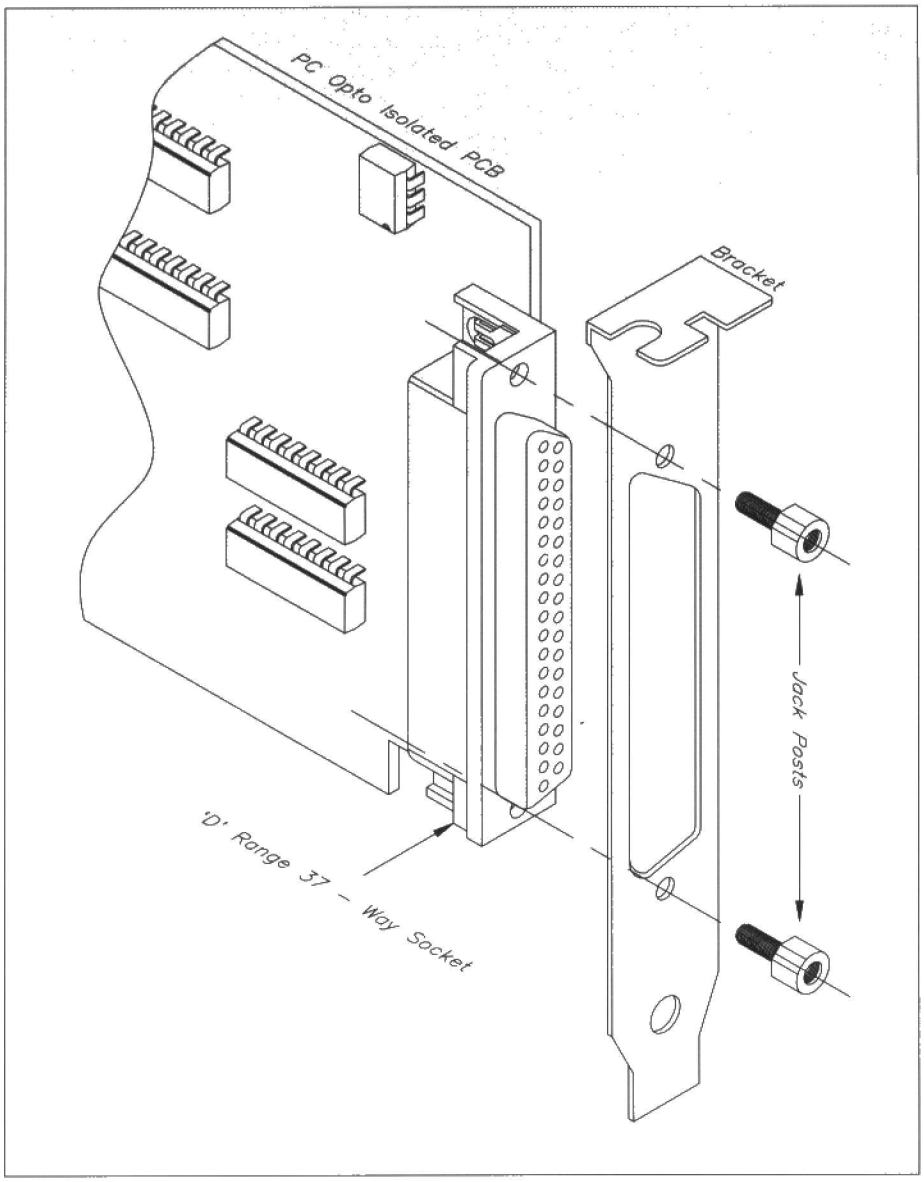


Figure 5. Connector mounting bracket assembly.

computer reads the port, then the data read may be undefined (not stable), and will be in error. In situations where this could cause a problem, double-buffering should always be employed.

If double-buffering is disabled, then input data strobing into IC3 from OP1 can also be disabled. This is done by configuring OP1 so that it is permanently activated, by tying pin 21 to pin 19 of PL1, and connecting pin 2 to pin 20 of PL1. In this case it should be noted that if the data input to OP2 and OP3 is changing at the exact time the computer reads the port then, as before, the actual data read will be undefined and inaccurate.

Finally, resistor R20 and capacitor C5 ensure that IC5 is loaded with IC3's data before the chip is taken out of the high impedance state, preventing any possible spurious data appearing on the data bus. Figure 3 shows the pin-outs of the 37-Way D-range connector PL1, which will be needed for reference when making external connections to the card.

Construction

The PCB is a double-sided, plated-through hole type, with a gold-plated edge connector, chosen for maximum electrical reliability and mechanical stability. However, removal of a misplaced component is quite difficult with this type of board, so please double-check each component type, value, and its polarity where appropriate, before soldering! The PCB has a printed legend to aid you in correctly positioning each item, see Figure 4.

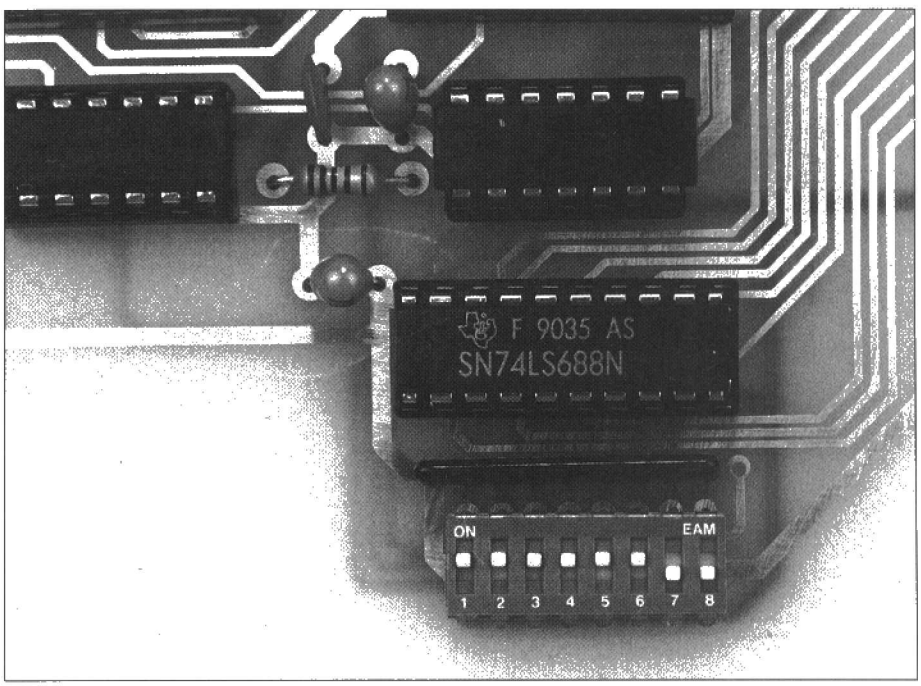
The order in which the components are fitted is not critical, however, the following instructions will make the assembly task as straightforward as possible. For general information on soldering and assembly techniques, please refer to the Constructors' Guide included with the Maplin kit.

During construction, be careful not to scratch the gold-plated edge connector or splash it with solder, as this is likely to affect operation of the card and computer.

Referring to the parts list and PCB legend, insert and solder all the resistors, not forgetting the resistor networks RN1 and RN2. For the latter, do make sure that the pin 1 marker aligns with the dot on the PCB in each case (this is the common terminal). This can be followed by the fitting of the diodes, taking care to match the cathode markers with the white blocks on the PCB legend. Insert and solder the two tantalum capacitors C1 and C2, taking care that the lead nearest to the + mark on the body is inserted into the hole adjacent to the + mark on the PCB. Next fit the remaining capacitors C3 to C5. Insert the slimline, 8-Way DIL switch SW1, ensuring that the 'on' side is facing inwards on the PCB. Next, insert the six IC sockets for ICs 1 to 6, ensuring that the notch on the sockets are aligned with the corresponding marks on the PCB legend. Note, there are no sockets for the five opto-isolator packages. Do not fit these or insert any ICs yet!

The remaining components can now be fitted approximately in order of physical size. Fit the fuse clips and fuse, then the 37-way D-range connector into the board and make sure that it is butted-up close to the PCB before soldering. It only remains for the optoisolator packages to be mounted, observing correct orientation with the legend and the normal precautions while soldering semiconductors. Insert all ICs into their sockets last, taking care to align the pin 1 designator on each IC with the corresponding notch in its socket.

An end-plate is supplied in the kit,



Close-up of the address setting switches.

Description	Hex Address PC/XT	PC/AT	
Fixed disk	n/i	1F0-1F8	
Games adaptor	200-20F	200-207	
Expansion unit	210-217	n/i	
2nd Parallel printer port	n/i	278-27F	
Alternate EGA	2B0-2DF	2B0-2DF	
GPIB (0)	2E1	2E1	*
Data acquisition (0)	2E2-2E3	2E2-2E3	*
Prototype card	300-31F	300-31F	
Fixed disk	320-32F	n/i	
Network card	360-36F	360-36F	
1st Parallel printer port	378-37F	378-37F	
SDLC	380-38F	380-38F	
2nd Bisynchronous	n/i	380-38F	
Cluster (0)	390-393	390-393	*
1st Bisynchronous	n/i	3A0-3AF	
Monochrome adapter/printer	3B0-3BF	3B0-3BF	
Enhanced graphics adaptor	3C0-3CF	3C0-3CF	
Colour graphics adaptor	3D0-3DF	3D0-3DF	
Floppy diskette controller	3F0-3F7	3F0-3F7	

* Note: These devices decode the full 16 address bits, allowing further devices to be located in the same category above 3FF, for example GPIB (1) = 22E1, etc.

n/i = not implemented

Table 1. Designated I/O addresses.

Required base address = 0300 hex

0300 hex = 11000000xx

x = don't care – as the PC Opto-Isolator Card does not decode the last two bits A1 and A0, their setting is irrelevant. Thus the DIL switch settings equate to address lines A2 to A9, as shown below:

Switch number:	SW1-8	SW1-7	SW1-6	SW1-5	SW1-4	SW1-3	SW1-2	SW1-1
Address line:	A9	A8	A7	A6	A5	A4	A3	A2
Binary value:	1	1	0	0	0	0	0	0
Switch setting:	OFF	OFF	ON	ON	ON	ON	ON	ON

Table 2. Address selection.

allowing the 37-way connector and the PCB, as a complete assembly, to be securely mounted to the back panel of your PC. This should now be fitted as shown in Figure 5.

Clean up the board by cutting off excess wires – no component lead should stand proud by more than 2mm – and with a PCB cleaner and a stiff paint brush, wash off any flux before inspecting the module. A close inspection of all tracks, joints and components is especially recommended on this board before you insert the card into your computer! Any mistakes and, well, you could be making an unscheduled visit your local computer repair shop!

Installation

Installation of the PC Opto-Isolator Card can be broken down into a number of steps.

1. Selecting an appropriate base address:

The I/O address area of an 8088/80286 machine is limited to 64K. The design of PCs reserves I/O addresses up to &H00FF for use on the motherboard, and makes available I/O addresses &H0100 to &H03FF for use on expansion cards.

When selecting an I/O base address, it is important to avoid those already in use by existing cards. If you have two or more cards both addressed at, say &H0300, 'bus contention' is likely to cause problems (the microprocessor is accessing two devices at the same time). For example, one card could be pulling the data lines high while another card is trying to hold them low, so that the data itself is meaningless.

Addresses already in use can be determined by consulting the installation instructions for the existing cards. In addition, Table 1 gives a helpful list of designated I/O addresses. It is suggested

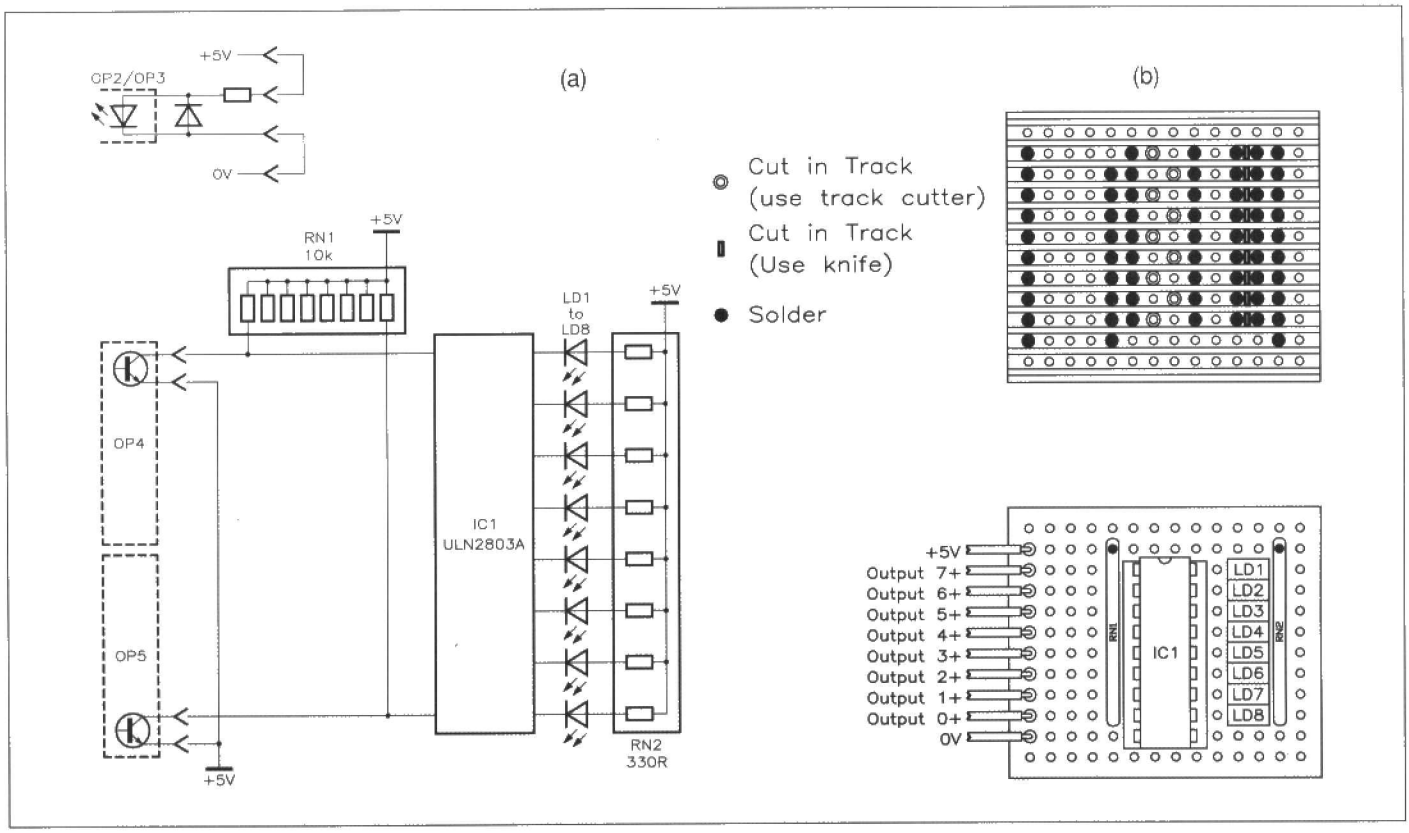
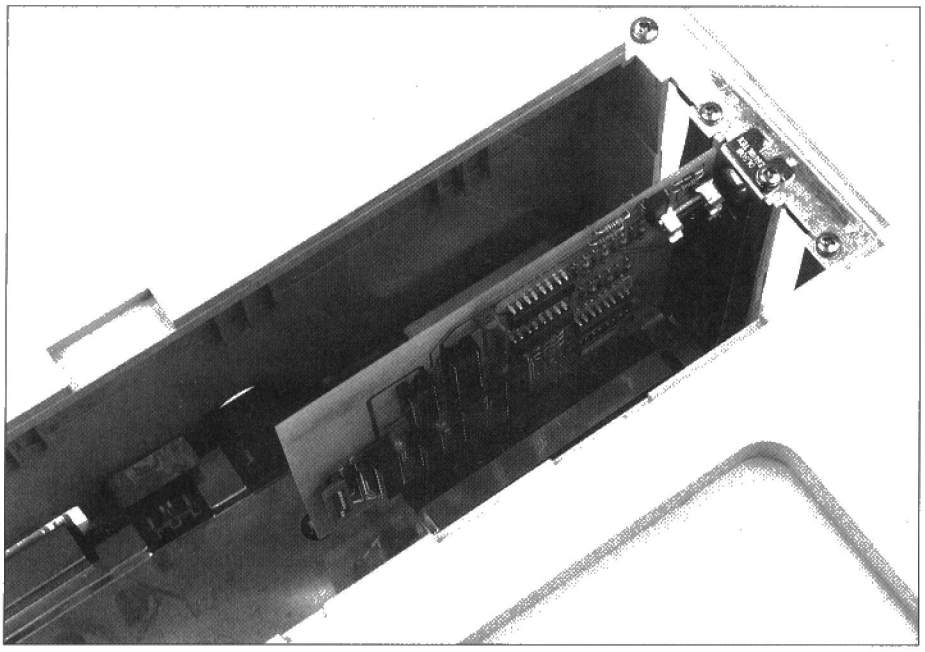


Figure 6a shows the suggested test circuit diagram; 6b shows the stripboard layout for the test circuit.



The PC Opto-Isolator Card installed in a computer.

that address &H0300 is used, as this is designated for prototyping cards. However, as the PC Opto-Isolator Card only occupies 4 bytes in the I/O memory map, up to 7 cards can be installed in the address space between &H0300-&H031F, giving a total of 56 optoisolated inputs and 56 optoisolated outputs!

The base address of the PC Opto-Isolator Card is set up as follows: The settings of SW1-1 to 8 can be determined by converting the required address into binary and taking the eight most significant bits (A9 to A2) as the settings for the switches. SW1-1 corresponds to bit A2 and SW1-8 corresponds to bit A9, a logic 1 = switch 'off' and a logic 0 = switch 'on'. An example of how to determine the switch settings is shown in Table 2. The switch settings on the prototype corresponded to a base address of &H0300. Note that even though the card only uses one address (its base address), the least significant two bits, A1 and A0, are not actually implemented. This results in the card's single equivalent address actually occupying four of the machine's address locations. This may seem rather odd, but is done in order that the card is given maximum versatility in the high-order bits, allowing the address range of expansion cards to cover &H0300 to &H03FC.

2. Turn off the computer and disconnect it from the mains supply. Lethal voltages reside inside computers, and installation of the card with the computer switched on may result in permanent damage to your computer and/or the card.

3. Remove the cover of your computer to expose the expansion card area.

4. Locate a suitable empty expansion slot and remove the metal blanking plate cover screw, and cover (if fitted). Store the cover in a safe place for later replacement, should you wish to remove the PC Opto-Isolator Card from your computer.

5. Carefully insert the card into the empty slot, pushing it fully home without forcing it. Using the cover screw removed in step 4, fix the end-plate to the back of your computer.

6. Double-check everything.

7. Replace the cover.

Testing

With all fingers, etc. crossed, switch on the computer – it should boot in the normal

```
100 BASEADD%=&H300              'Set up base address for card
110 DAT%=INP(BASEADD%)          'Read data in from card
120 PRINT DAT%                  'Print data on screen
130 GOTO 110
```

Listing 1. Simple program to test inputs.

```
100 BASEADD%=&H300              'Set up base address for card
110 OUT BASEADD%,&HFF           'Turn all optoisolators on
120 PRINT "All outputs on"
130 GOSUB 180                   'Call delay subroutine
140 OUT BASEADD%,0              'Turn all optoisolators off
150 PRINT "All outputs off"
160 GOSUB 180                   'Call delay subroutine
170 GOTO 110
180 FOR F=1 TO 5000             'Delay subroutine
190 NEXT F
200 RETURN
```

Listing 2. Simple program to test outputs.

```
100 DAT%=INP(BASEADD%)          'Read data on OP2/OP3
```

Listing 3. Example BASIC line to read inputs.

```
In hex:
100 OUT(BASEADD%),&H13          'Turn outputs 1,2 & 8 on, 3-7 off

In decimal:
100 OUT(BASEADD%),19            'Turn outputs 1,2 & 8 on, 3-7 off
```

Listing 4. Example BASIC line to set outputs.

Opto number =	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Decimal value =	128	64	32	16	8	4	2	1

For example, to turn optos 3, 4 and 7 on, and optos 1, 2, 5, 6 and 8 off:

Opto number =	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Decimal value =	128	64	32	16	8	4	2	1
Binary value =	0	1	0	0	1	1	0	0

= 64 + 8 + 4
= 76 decimal
= 4C hex

Table 3. Corresponding values for input and output lines.

$$Rseries = \frac{Vin - Vf}{If}$$

Where Vf = 1·2V and If = 5·5mA

Rext = Rseries – 680Ω

Choose the nearest preferred value lower than that calculated.

Table 4. Calculating series resistors for various input voltages.

way. If it does not, turn it off immediately, remove the expansion card and check for solder whiskers shorting out adjacent tracks.

A simple program written in BASIC can be used to test the card, see Listings 1 and 2. The first program simply displays the decimal value of the data presented to OP2 and OP3 on the screen. Figure 6a shows a test connection, allowing each input of OP2 and OP3 to be checked. The second program turns all outputs (OP4 and OP5) on and then off again at short intervals. Each of the eight outputs can be checked with the test circuit shown in Figure 6b. The delay may be adjusted to alter the switching speed of the optoisolators; this is achieved by altering the number in line 180, presently set at 5000. A lower number will decrease the switching interval, a higher number will have the opposite effect.

Applications for the Opto-Isolator Card

The uses to which this card can be put are primarily where electrical isolation is required between the PC and the circuitry to which it is connected. These can include the switching of individual optocoupled outputs, calculating decimal output value to switch the required opto, also calculating corresponding values for inputs (Table 3).

Figure 7 shows different ways to input data into the Opto-Isolator Card, while Figure 8 shows different output configurations. For instance, the switching of relays, motors, solenoids, etc. is possible, but

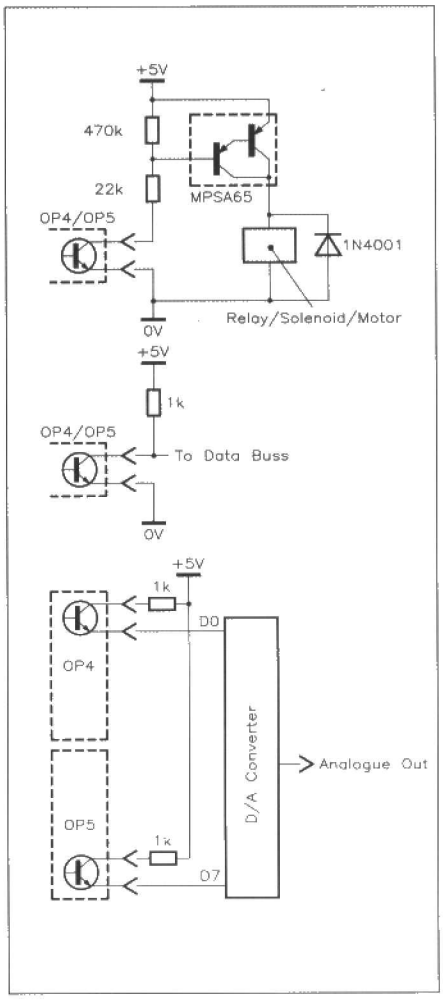


Figure 8. Example output circuits.

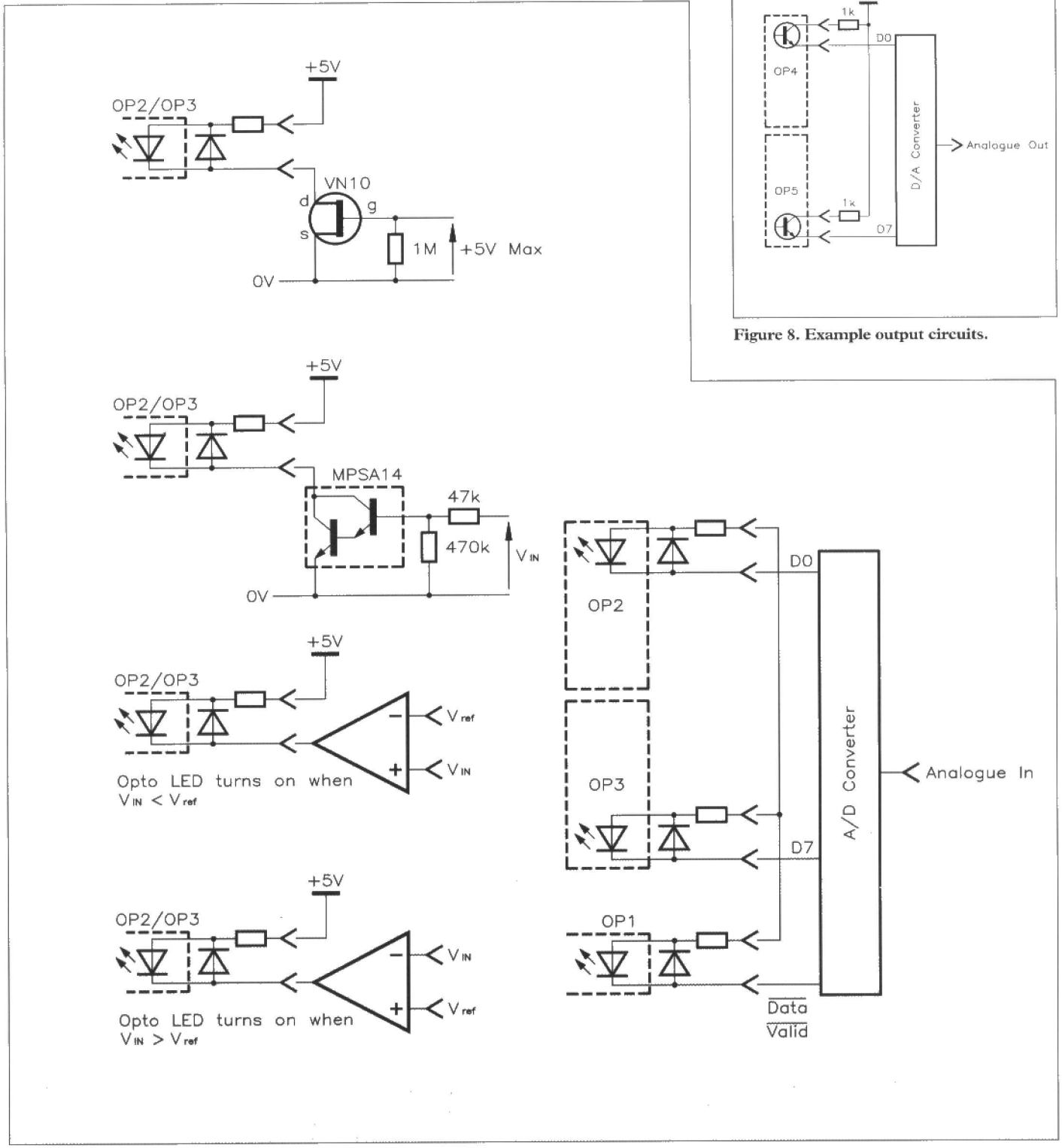


Figure 7. Example input circuits.

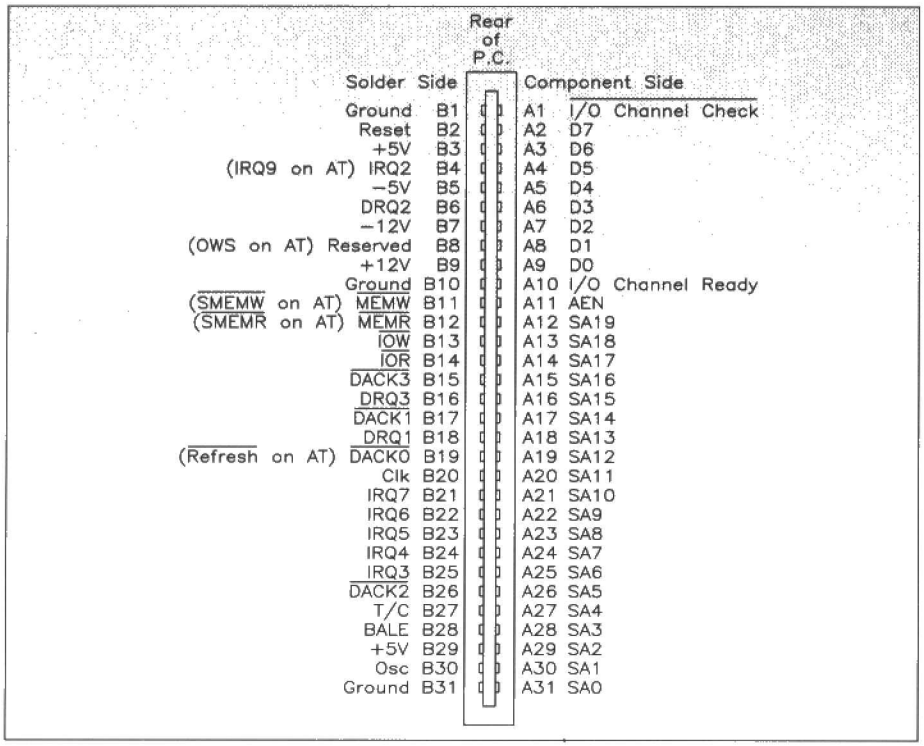

Rear of P.C.
Solder Side
Component Side
Ground B1 A1 I/O Channel Check
Reset B2 A2 D7
+5V B3 A3 D6
(IRQ9 on AT) IRQ2 B4 A4 D5
−5V B5 A5 D4
DRQ2 B6 A6 D3
−12V B7 A7 D2
(OWS on AT) Reserved B8 A8 D1
+12V B9 A9 D0
Ground B10 A10 I/O Channel Ready
(SMEMW on AT) MEMW B11 A11 AEN
(SMEMR on AT) MEMR B12 A12 SA19
IOW B13 A13 SA18
IOR B14 A14 SA17
DACK3 B15 A15 SA16
DRQ3 B16 A16 SA15
DACK1 B17 A17 SA14
DRQ1 B18 A18 SA13
(Refresh on AT) DACK0 B19 A19 SA12
Clk B20 A20 SA11
IRQ7 B21 A21 SA10
IRQ6 B22 A22 SA9
IRQ5 B23 A23 SA8
IRQ4 B24 A24 SA7
IRQ3 B25 A25 SA6
DACK2 B26 A26 SA5
T/C B27 A27 SA4
BALE B28 A28 SA3
+5V B29 A29 SA2
Osc B30 A30 SA1
Ground B31 A31 SA0

Figure 9. Edge connector pin-outs.

more useful is the ability to handle binary encoded data. The optocoupling technique makes high immunity to noise and interference possible in communication between the PC and the external equipment. The actual LED current is dependent on the energising voltage and the value of limiting resistors R10 to 18, and Table 4 shows how to choose alternative resistor values for energising voltage levels other than 5V.

Other applications can include controlling electrical apparatus around the house, giving the impression that the house is occupied. Process control includes controlling various things depending upon the state of various other things. In robotic applications, each input can be linked to a sensor and each output can be linked to articulate movement.

Figure 9 shows the pin-outs of the plug-in card edge-connector, which may be useful for trouble-shooting and shows the PCs various buses and control lines. With the Opto-Isolator Card you've basically got eight outputs, eight inputs, a strobe bit, and 5V at 1A available.

PC OPTO-ISOLATOR CARD PARTS LIST

RESISTORS: All 1% Metal Film (Unless specified)			
R1-8,10-18	680Ω	17	(M680R)
R9,19	10k	2	(M10K)
R20	150Ω	1	(M150R)
RN1,2	SIL Resistor 10k	2	(RA30H)
CAPACITORS			
C1,2	10µF 16V Tant	2	(WW68Y)
C3,4	100nF 16V Minidisc	2	(YR75S)
C5	100pF Ceramic	1	(WX56L)
SEMICONDUCTORS			
D1-9	1N4148	9	(QL80B)
IC1	74LS688	1	(KP49D)
IC2	74LS02	1	(YF02C)
IC3	74HCT533	1	(UB88V)
IC4	74LS273	1	(YH00A)
IC5	74LS374	1	(YH16S)
IC6	74LS00	1	(YF00A)
OP1	Opto-Isolator	1	(WL35Q)
OP2-5	Quad Opto-Isolator	4	(YY63T)
MISCELLANEOUS			
	14-Pin DIL Socket	2	(BL18U)
	20-Pin DIL Socket	4	(HQ77J)
	Fuse Clip 20mm Type1	2	(WH49D)
FS1	Fuse 20mm 1A	1	(WR03D)
SW1	Slimline 8W DIL Switch	1	(QY70M)
SK1	RA Socket 37-Way D-Range	1	(JB38R)
	PC Bracket 37-Way D-Type	1	(CR45Y)
	PCB	1	(GH23A)
	Instruction Leaflet	1	(XT87U)
	Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items are available as a kit, which offers a saving over buying the parts separately.

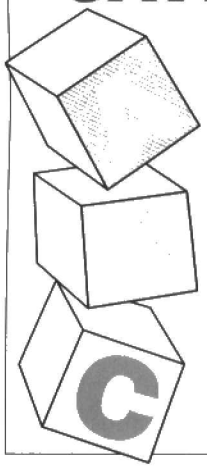
Order As LT17T (PC Opto-Isolator I/O Card) Price £27.95.

The following new items (which are included in the kit) are also available separately, but are not shown in the 1993 Maplin Catalogue.

PC Bracket 37-Way D-Type **Order As Price CR45Y £2.25.**

Opto-Isolator PCB **Order As GH23A Price £7.95.**

SAVE £££'s ON KITS & COMPONENTS



If you would like to **SAVE £££'s** whenever you purchase kits, components or other goods from Maplin, then follow our *'as easy as ABC'* guide to saving money!

Ask yourself – "Since I buy 'Electronics' regularly, why don't I take out a subscription? – it'll save me up to **£4.52*** and I'll have each issue delivered to my door **Free of Charge** *before* it's available in the shops!"

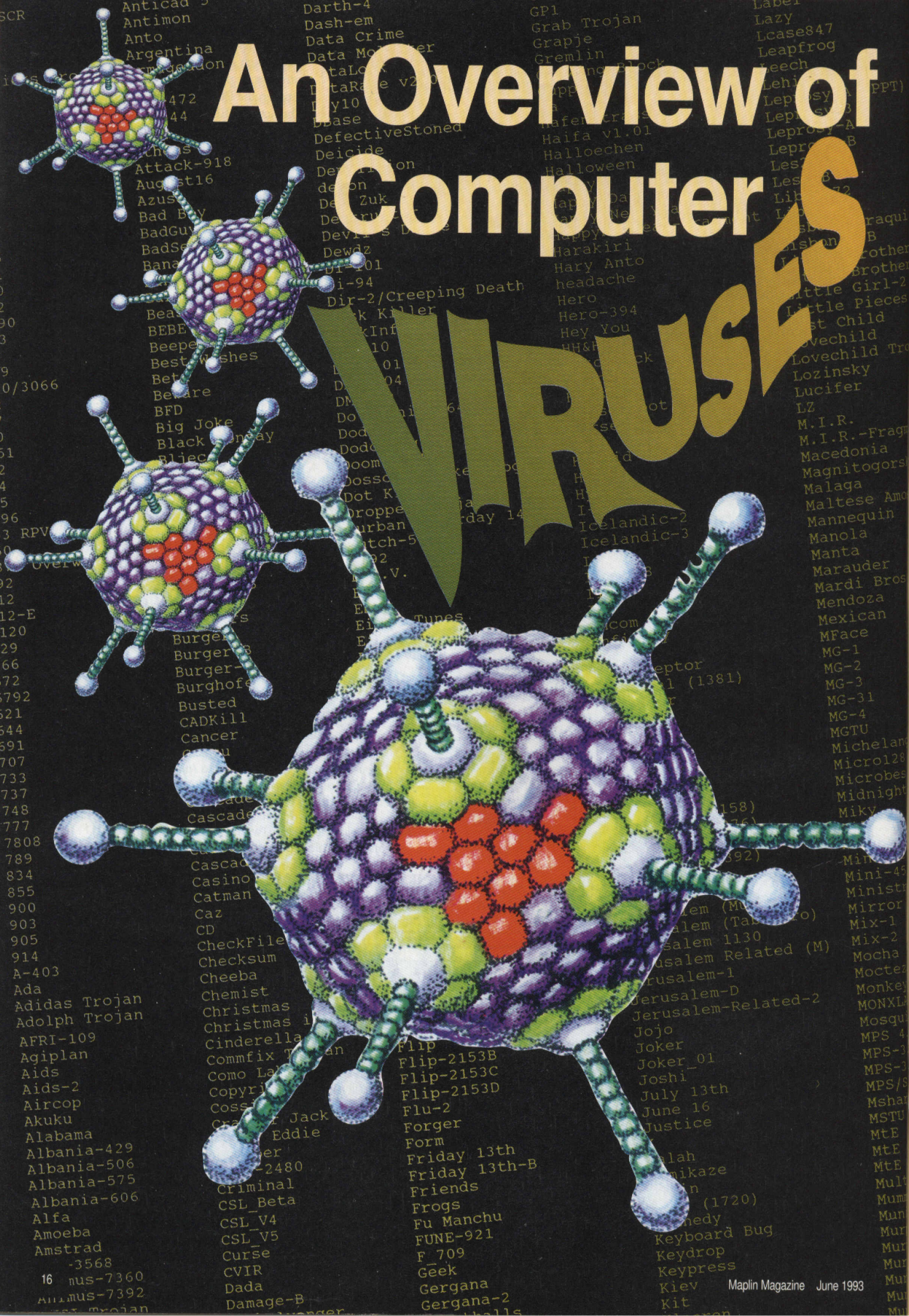
Benefit – I'll also *benefit* from having a **Subscriber's Exclusive 5% Discount Club Card** that I can use, with a few exceptions**, on purchases of over £20 from Maplin."

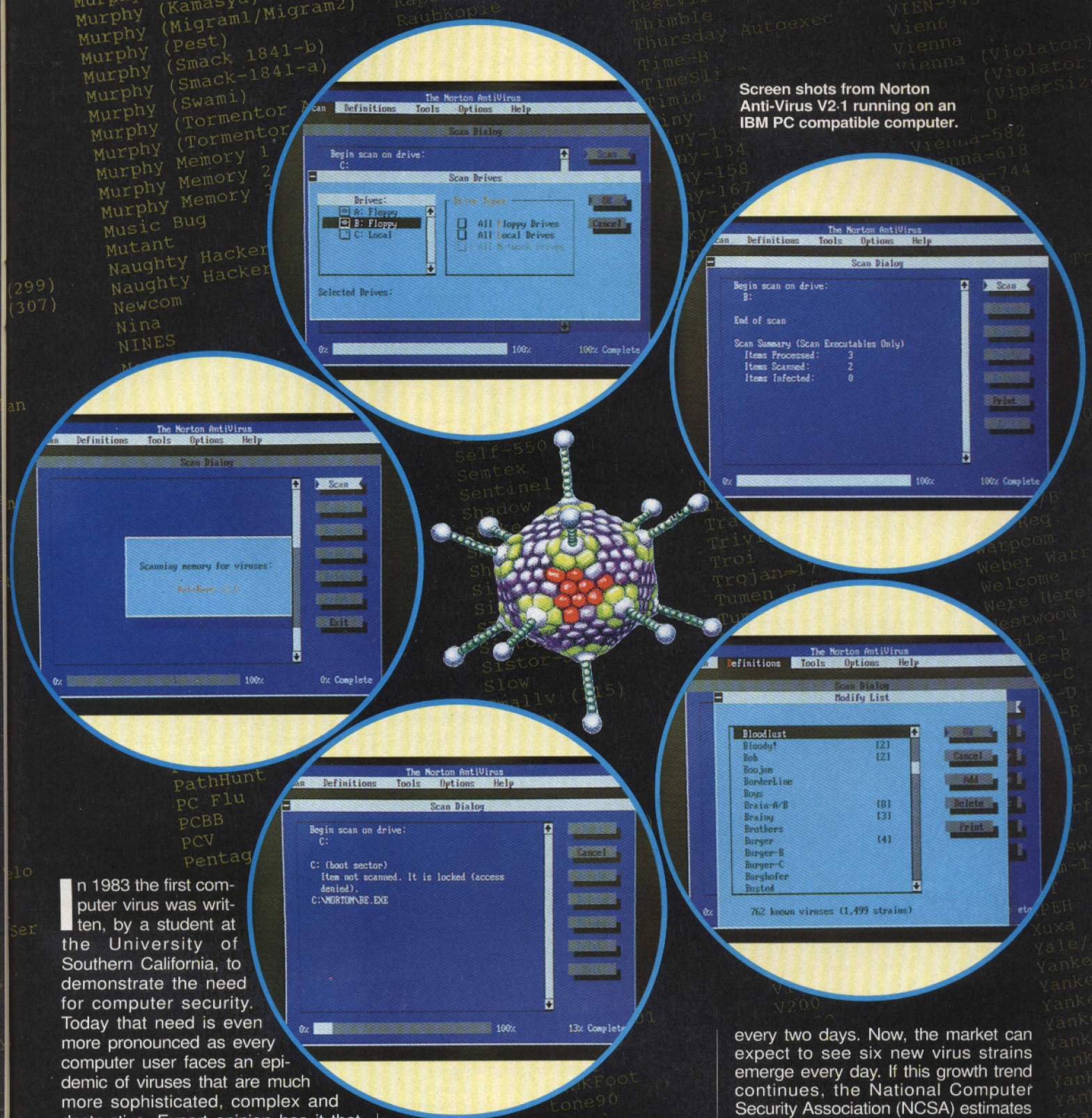
Complete – "All I have to do is *complete* the subscription form on page 21 of this issue, *what could be easier!"*

SAVE £££'S ON KITS and COMPONENTS – IT'S AS EASY AS ABC!

* A saving of £4.52 is based on a Direct Debit or Continuous Credit Card Subscription that includes two free issues worth £3.50 and a subscription saving of £1.02.
**Full details on how to make the most of the discount card are supplied with the card. Full terms and conditions are available on request.

An Overview of Computer VIRUSES





Screen shots from Norton Anti-Virus V2·1 running on an IBM PC compatible computer.

In 1983 the first computer virus was written, by a student at the University of Southern California, to demonstrate the need for computer security. Today that need is even more pronounced as every computer user faces an epidemic of viruses that are much more sophisticated, complex and destructive. Expert opinion has it that the average incubation period of a newly written virus is two years. As the law of biological virus survival dictates, the next generation of computer viruses will overcome the flaws of today's viruses and adapt to current anti-virus technology. The market faces successive generations of viruses that will have the bugs worked out – with devastating potential for widespread damage.

All PC users (or rather their machines) are at risk from virus infections. The proliferation of local area networks (LANs); the increased reliance on PCs to store critical data; the downloading of information from mainframes to desktops; the arrival of electronic bulletin boards; the growing use of remote communications; the casual spread of software via piracy; the increased sophistication of users; the portability of data; and the staggering rate of new virus creation all contribute to the increased risk of virus infection.

As consumer vulnerability to viruses has increased, so has consumer awareness and sometimes panic. Indeed there have been articles on viruses and virus protection in general business publications such as The Financial Times, The Times, The Wall Street Journal Europe and Business Week International, not to mention the many computer trade publications that regularly publish articles and devote entire columns to the subject.

In 1986 four viruses were known to exist, with new ones being created at the rate of one every three months. In 1989, a new virus appeared once every week. By 1990, this rate had increased to one every two days. Now, the market can expect to see six new virus strains emerge every day. If this growth trend continues, the National Computer Security Association (NCSA) estimates that by 1994 about 38,700 different viruses will be in circulation.

At the time of writing, there are well over 1,500 virus strains that can potentially infect IBM PC compatible computers, other platforms, such as Apple Macintosh, are similarly at risk. It is widely believed that the 10 most common viruses account for approximately 95% of all computer infections. According to the Computer Virus Industry Association (CVIA), the 10 most common viruses are Stoned, Jerusalem, Disk Killer, Joshi, Cascade (1701), Dark Avenger, Ping Pong, Sunday, Pakistani Brain and Music Bug.

Records taken by the CVIA show that in the year to October 1989 nearly 200,000 machines were infected in the US. However, the actual total is presumed to be much higher since many

virus experts believe that only one in 100 cases is reported. Research done by the NCSA into 2,500 large corporation sites with 400 or more microcomputers revealed the following: 50% of the firms surveyed had had a virus infection; 3·

3% had an infection during 1988 or earlier, 11% had an infection in 1989, 19% had an infection in the first or second quarters of 1990, 16% had an infection in the third quarter of 1990, 25% had an infection in the fourth quarter of 1990; only 10% of these large corporations had any form of virus protection; and 13% had more than 25 machines infected at one time. A separate virus study of Fortune 200 companies found that 35% of surveyed departments had an average of two viruses last year.

The costs of damage from virus infections are staggering in terms of lost information, lost computing time and staff time spent in the recovery process. Assuming that the average incident destroys 20 megabytes of data which must be re-entered, and assuming normal rates of pay for those who must re-enter the information, the cumulative cost of virus damage to US industry alone is estimated at £305 million. This figure does not take into account the inestimable value of the information lost. Furthermore, industry analysts estimate that almost 90% of affected organisations experience reinfection within 30 days.

According to a recent NCSA study, the US ranks second in virus authorship (11%). Bulgaria maintains the highest level of virus authorship (18%), followed by Germany (9%), Israel (8%), Spain (5%) and The Netherlands (5%).

Obviously, viruses present a special threat to networks because of their inherent connectivity and the potential for widespread devastating data loss. Experts say that once a virus infects a single networked computer, the average time required for it to infect another node is 10 to 20 minutes. With a propagation time of less than 20 minutes, some virus strains can wipe out an entire network in several hours.

Virus Industry Issues

Despite the growing awareness of the computer virus threat and the need for protection, most computers and networks remain unprotected. Many people neglect to purchase virus protection devices in the belief that the providers of anti-virus software are out for personal gain, and are involved in the threats. There is also the widespread thought that bad things always happen to someone else.

A study into the concerns of virus detection software by the buyers of such items showed: the highest concern to be the product's ability to protect against all viruses (96%), product reliability (94%), ability to scan floppy disks and hard disks (92%), quick upgrades (90%), the ability for the program to detect its own infection (90%), compatibility with other applications (89%), quality of virus reporting (85%), the ability to repair an infected application (85%), transparent operation (80%), and the ability to operate on a network (78%).

The National Institute of Standards and Technology (NIST) in the US has established an industry and governmental consortium to combat computer viruses. The consortium hopes to get the industry back to its basic responsibility of providing software and hardware products, rather than virus solutions. Additionally, the NCSA has formed the Anti-Virus Product Developers Consortium (AVPD) to improve the exchange of information among virus researchers, product developers and the public.

Types of Virus

A computer virus is a computer program written to carry out a single mission: to replicate. Viruses accomplish their reproductive task be preying on other computer files, and require a host program to survive. The host can be an application, part of the operating system, part of the system boot process or a device driver. Most commonly, viruses attach to executable programs, .COM and .EXE files. Viruses gain control over the host in various ways, including attaching infected code to the end of the host program and misguiding the header information at the beginning of the file to point to the virus rather than the program. Then, when the infected host program is initiated, the virus gets executed before the host. The virus continues to propagate, spreading from file to file. Some viruses are programmed with a trigger mechanism for causing damage. A trigger condition may be linked to the number of times that file is run, or it may be a response to a particular date, time or random number. It is at this point that the virus begins to carry out its programmed mission of data destruction.

There are several types of viruses classified according to their propagation patterns:

★ Executable File Infectors – spread infection by attaching to executable files (.EXE, .COM, .SYS, .OVL or .BIN) in such a way that the virus code gets executed. For example, the virus may misdirect the header of a file and execute its own program code before the host field.

★ Boot Sector Infectors – overwrite the original boot sector, which is executed when the computer is turned on. The virus replaces a portion of the boot sector with its own infectious code so it will load first at system boot (before DOS) and get control. Usually these viruses load themselves into memory and monitor all access calls, infecting additional programs as they are accessed. To spread, boot sector viruses require the system to boot from an infected floppy disk.

★ Partition Table Infectors – attach to the hard disk partition table by moving it to a different sector and replacing it with the virus. Upon system boot, the virus loads into memory and monitors access calls, infecting programs as they are accessed.

Because a virus is nothing more than a program attached to another, it can be easily spread in the same ways legitimate software is normally distributed. Viruses have occasionally been transmitted through shrink-wrapped retail software. Sales representatives often act as carriers when they unknowingly demonstrate infected programs. Newly purchased computers, with their hard disks formatted by service technicians, can be infected. Viruses travel over telephone lines through programs sent by modem. Bulletin boards occasionally transmit viruses. The most common way a virus spreads is through the sharing of floppy disks, and, often, software piracy.

Virus effects can range from no visible damage, to complete and obvious

data destruction, or the more insidious randomly selected destruction. Today's sophisticated viruses camouflage themselves so well, that often, there are no indications of their presence. The most common visible indicators of virus infection are: changes in program length; changes in the date or time stamp; longer program load times; slower system operation; unexplained disk activities; unexplained reduction in memory or disk space; bad sectors on a floppy disk; disappearing programs; frequent, unusual error messages; unusual screen activity; access lights turn on for a non-referenced drive; and failed program execution.

Protection Methods

Today there are three broad-based categories of anti-virus techniques: scanners, memory-resident monitors and differential detectors.

Scanners may be general or specific in nature with regards to the virus signatures that they look for. Scanners are designed to check files and other areas of the disk (such as boot sectors, partition tables), memory, and other hiding places for specific code patterns that are typical to known virus strains. In many cases these products are capable of activating a virus removal routine. The advantage of scanners includes their ability to provide a precise identification of a virus present in the system and their ability to detect a virus before it is executed.

On average, the 10 most common viruses cause 95% of all infections, so a scanner may be 95% effective against the top 10 virus strains. However, scanners are completely ineffective against any virus whose code pattern is not recognised. Thus scanners are quickly outdated and require frequent, costly and time consuming updates – which may be available only after serious damage has been done. Additional drawbacks to this method are the inability to detect virus mutations, and speed, which is usually proportional to the number of viruses being scanned.

Memory resident monitors are typically programs that watch for suspicious DOS behaviour (checking each program before it is run for illegal system calls, writes to the boot sector, or modification of executable files), and preventing the execution of infected programs through system activity monitoring.

These monitors are not effective against unknown viruses. Other drawbacks to this method include the high memory overhead, slower operating speed because they must check each program before it is run, a high false alarm rate, and potential application incompatibility. Additionally, because monitors are RAM resident, they can easily be defeated by a virus patch to the program. A monitor may not be able to prevent a boot sector infection if the infection occurs before the monitor has a chance to load.

Differential detectors are used to signal unwanted change in program files by comparing a file's signature. Each file has a unique signature in the form of a CRC or checksum. Changes in any character within the file will probably change the file's checksum. By recalculating the file's checksum and comparing it to the original, differential detectors can detect file changes.

Some products on the market that use this methodology have loopholes through which viruses can attack. Some of them only check the beginning and the end of program fields, and some leave their databases visible and exposed. Still others use industry standard CRCs or checksums to calculate file signatures – a signature which can be forged by a virus cannot provide full protection.

There is now a group of intelligent virus detection and removal tools, for the PC and networks marketplace, that incorporates several virus protection methodologies: memory resident monitor, scanner and file modification detection. This software has a patented generic recovery method which provides 100% safe restoration of all recoverable infected files, even those hit by an unknown virus.

- ★ Do you have difficulty in getting hold of your copy of *'Electronics – The Maplin Magazine'*?
- ★ Does your Newsagent always sell out before you can get your copy?
- ★ Are you fed up with braving the onslaught of wind, rain and keep fit fanatics in your ceaseless quest to find a copy of your favourite electronics magazine?
- ★ Do you say to your family and friends, "I'm just going outside, I may be gone a little while. . ."?
- ★ Does your dog hide when you return empty handed?
- ★ Do you resort to reading the Beano, Dandy, Viz or other well known 'comics'?

***Then why not ask your friendly local Newsagent to reserve or deliver every issue of* 'Electronics – The Maplin Magazine'?**
***Fill out the coupon (below), hand it to your Newsagent and you need never miss an issue of* 'Electronics – The Maplin Magazine'.**

Dear Newsagent

Please reserve/deliver (delete as applicable) each issue of *'Electronics – The Maplin Magazine'* for me.

Name _____

Address _____

_____

Signature _____

'Electronics – The Maplin Magazine' is published monthly and is distributed through your wholesaler by: United Magazine Distribution Ltd., 1 Benwell Road, London N7 7AX. Telephone: 071-700-4600.

A readers forum for your views and comments. If you want to contribute, write to:

The Editor, 'Electronics – The Maplin Magazine' P.O. Box 3, Rayleigh, Essex, SS6 8LR.

Dear Editor AIR YOUR VIEWS

Don't Understand It but I'm Impressed

Dear Sir,
I will be the first to admit that I am not exactly an expert when it comes to electronics. Only in the last week or so have I made a serious start in educating myself in the ways of electrons and semiconductors, so it will not surprise you to hear that many of the circuit descriptions which accompany your projects seem very much like gobble-degook to me! Strangely, though, I can get to grips with what I term 'black box' engineering; using chips that do relatively complex tasks with only a capacitor here, and a resistor there, to mould the way a chip works.
This aside, I get vast pleasure out of taking a load of small black, blue and silver plastic things (each with between two and twenty odd legs), joining them with molten lead, connecting a battery and watching them do something – whether or not I understand *how* they are doing it. For your (generally) excellent projects and modules I thank you most sincerely.
Jeff Moye, Essex

Personally I like to see circuit descriptions in the project write-ups since this serves both educationally and as an aid to fault-finding. Although you can't make much sense of circuit descriptions at the moment, they will – in time – further your understanding and enjoyment. There are many beginner's books in the 'Books' section of the current Maplin Catalogue which will help (unless you're a masochist, try to avoid books for students, which tend to treat everything mathematically!).

About Labels and Amplifiers

Dear Sir,
I must firstly congratulate you on an excellent magazine. As a hobbyist I get great enjoyment from building your projects, but here are a couple of things I would like to bring to your attention.
In Issue 62 (February) Mike Moulton suggested a sticky label for the front of projects. This would be an excellent idea as it would give the project an even more professional look, and it would also save us having to use graphic transfers which sometimes, if you're not careful, end up slightly 'squint!'
About 10 years ago I was in need of a stereo system so, looking through the Maplin Catalogue at that time, I came across the 25W MOSFET Amplifier. I bought the kit and built it. It's the best purchase I ever made, as the sound quality exceeded any other commercial amplifier, but unfortunately this kit is now discontinued. Is there any chance that this amplifier would appear in a '2nd Time Around' feature?
Alan S. Smith, Aberdeen.

A little more encouragement for the 'Maplin Label' idea. Any more support? As for the amplifier, I will agree that it always seems to be impossible to get reasonable performance and utilities in a 'modest' package, and I am talking about commercial amplifiers as can be bought in electrical stores. One has to buy the top-of-the-range item in order to get the design quality, state-of-the-art components and all the ancillary functions needed. I don't see why modestly powered amplifiers for average domestic use in the home can't be as well equipped (which is, of course, why you build your own, isn't it?). However, several Maplin amplifier kits are in the process of being updated and improved. If you fancy something rather different though, but in the same category as the old 25W MOSFET amp, then if you can hold on until the end of the year we shall be publishing details for an AFFORDABLE (yes, that is a dig at the Hi-Fi industry) high-quality 20W amplifier using valves – the original field-effect devices!

★★★★★★★★★★★★★★★★

S•T•A•R L•E•T•T•E•R

This month's Star Letter Award winner of a £5 Maplin Gift Token is Derek Noel Bonner of Lingfield, Surrey, whose wartime RSGB membership certificate appeared in the Magazine!

It's a Small World, Isn't It?

Dear Sir,
Having followed, with great interest, Mr Ian Poole's articles on the History of Amateur Radio, imagine my astonishment on turning to page 60 of Issue 61 (January), and seeing a reproduction of the membership certificate, issued to me by the Radio Society of Great Britain in 1944, signed by President at the time, Mr Ernest Lett Gardiner.
I was puzzled and not a little flattered to discover that this certificate had somehow become part of the RSGB's valuable archive material.
I remained a member of the RSGB for about 25 years although never achieving transmitting status. On resignation, I offered the society my collection of RSGB Bulletins and Wireless World Magazines. These were handed over t o an official of the society when he called to see me. I can only conclude that the membership certificate found its way back to the society at that time.
As a keen radio constructor since boyhood in the 1930s, I have been able to realise a long-standing ambition to build an electronic organ, interest having been re-awakened by publication of Dr Ryder's articles in the Wireless World in 1978 and by the Maplin ME553/54 design which followed. I joined the Electronic Organ Constructor's Society at about that time and have remained a member, and a Maplin customer ever since.
I have derived much enjoyment and enlightenment from the Maplin Magazine and value the Maplin mail order service highly.
Keep up the good work!

Which just goes to prove that, when you think you've seen the last of something, it turns up again when least expected.

★★★★★★★★★★★★★★★★★★★★

Mobile Message Display

Dear Editor,
I couldn't believe it that a letter I wrote to you was actually printed in the Star Letter column of Issue 61 (January). It encouraged me to forward a few more suggestions for your mag!
You're asking for ideas for your LED Moving Message Display (it's frustrating that we have to wait for *four* editions before the complete series is finished). How about a message display for the car, wired as an extra high-level brake light and message display?
It might operate as follows: brake pedal depressed, displays 'BRAKE' then all LEDs light as a full auxiliary brake light. Handbrake on, it displays 'STOP'. Accelerator pedal released, it displays 'SLOW'. Wired up to the car alarm, it displays 'HELP I AM BEING STOLEN' or something similar. Other messages which could be thrown up on demand might include 'IDIOT', 'FOOL', etc. (at risk of receiving a fat lip!).
Mr D. Lee, Birkenhead, Merseyside.

These are interesting ideas, but we are not sure how such a display will fit in with vehicle lighting regulations. If there are any Traffic Police Officers amongst the readership, perhaps they can comment?

Mystical SCART

Dear Sir,
I note with gratitude that you are preparing an index to the Maplin Magazine. I will willingly pay for this when it is ready! However, my current problem is getting information about SCART connections; please can you tell me in which issues references to SCART sockets are made? Do any of the Maplin publications give SCART details?
E. Vernon King, Cornwall.

See page 228 of the current (1993) Maplin Catalogue for info on the Peritelevision (SCART) Audio-Visual Interface Standard, showing connections and pin definitions. A feature on this subject will appear in the magazine sometime in the near future (sorry, can't be more specific than that).

When Is a Log Not a Log? When It's Wrong...

Dear Editor,
On receiving the April issue of 'Electronics' (issue 64) I was greatly interested in reading the 'Guide to Professional Audio' feature by Tim Wilkinson. However, in doing so I spotted what seems to be a 'deliberate' mistake on page 37, where if, as stated:

$$N\,Bel = \log_{10}\frac{P_1}{P_2}$$

then surely

$$NdB = 10\log_{10}\frac{P_1}{P_2}$$

and NOT

$$NdB = \log_{10}\frac{P_1}{P_2}$$

as printed. Do I get any 'Brownie Points' or prizes for spotting this 'deliberate', 'April Fool's Day' error?
Keith Duncan, Dundee.

No! It is your duty as a loyal reader to help us trap these things. But it got your letter printed, didn't it?

Oops Again!

Dear Sir,
Thank you for publishing my handy hints on page 23 of Issue 60 (December). Unfortunately you omitted the formulae and last paragraph at the end of hint 3, i.e. RCT Reciprocal = Rs Reciprocal = Reciprocal. 2 + RCT and Rs are transposed, the numerical result will still be current, but the minus sign in the answer should then be ignored.
The omission of the formulae has made nonsense of the hint and I have already had telephone calls from three of your readers who have taken the trouble to contact me to find out how to use the hint.
D. A. Castleton, Bramford, Ipswich.

That bit obviously went into the bin by mistake during page make up. Sorry about that.

Fax Clarification and More on the PC

Dear Sir,
With respect to R. E. Gosling's letter in issue 65 (May) regarding confidential fax transmission; whilst he is correct in that most fax manufacturers provide an ID number on their machines, it is incorrect to say that this feature provides confidential transmission and reception. Its purpose is to provide restricted access to the machine in the form of a 'Closed User Group'. However, this does not prevent received documents dropping out for all to see.
On the other hand encryption 'scrambles' the actual fax code prior to placing it on the telephone network, rendering it useless to any receiver without the correct decoding equipment.
On another note, regarding the current complaints about the lack of 8-bit computer projects, I would just like to say that the advantage of the PC is that, to all intents and purposes, it has a common expansion slot irrespective of the manufacturer, thus making any 'third party' device usable to virtually any user. Compare this to the height of the 8-bit home computer boom, when manufacturers of machines which even used the same processors had different expansion slots in terms of size and pin allocations, not to mention differing memory layouts. This meant constructors having to modify designs to suit their particular machines.
The PC has been with us for over ten years now and, as you rightly say, good second-hand machines are available for attractive prices, and are still heavily supported by the software industry. Perhaps a 'Back to Basics' series on home computers and interfacing may be in order?
K. Boothby, Gwynedd, Wales.

Thank you for your comments and, as you suggest, we hope to do something of this sort in the (near?) future.

2nd Time Around

Particular projects from the Maplin range have proved themselves to be very popular, but technology and component specifications have a habit of changing, with the result that some of these projects are in danger of becoming obsolete. Even if this were not the case, it may be equally worthwhile improving the project in question in order to increase its versatility and usefulness, and bring it 'up-to-date'. The '2nd Time Around' series is dedicated to reviewing and improving original, popular Maplin projects by republishing them with the necessary updates and improvements, ensuring their continued availability. This time it is the turn of the Minilab.

Original Design by Graham Dixey
Maplin Development by
Alan Williamson and Dennis Butcher
Text by Martin Pipe

The Minilab power supply has been a very popular project in the years that have elapsed since the design was originally published ('Electronics', September 1983). The kit has now been updated and the specification improved. The most important change is that a PCB is now available, to make construction considerably easier.

THE MAPLIN MINILAB

FEATURES

* Wide Variety of Power Supplies ±5V, ±12V, −15V and +1·25 to 24V Variable * Eight LED TTL-Logic State Indicator * Eight TTL-Logic Test Outputs * 1Hz/1kHz TTL-Level Oscillator * Debounced TTL-Level Switch with Complementary Outputs

APPLICATIONS

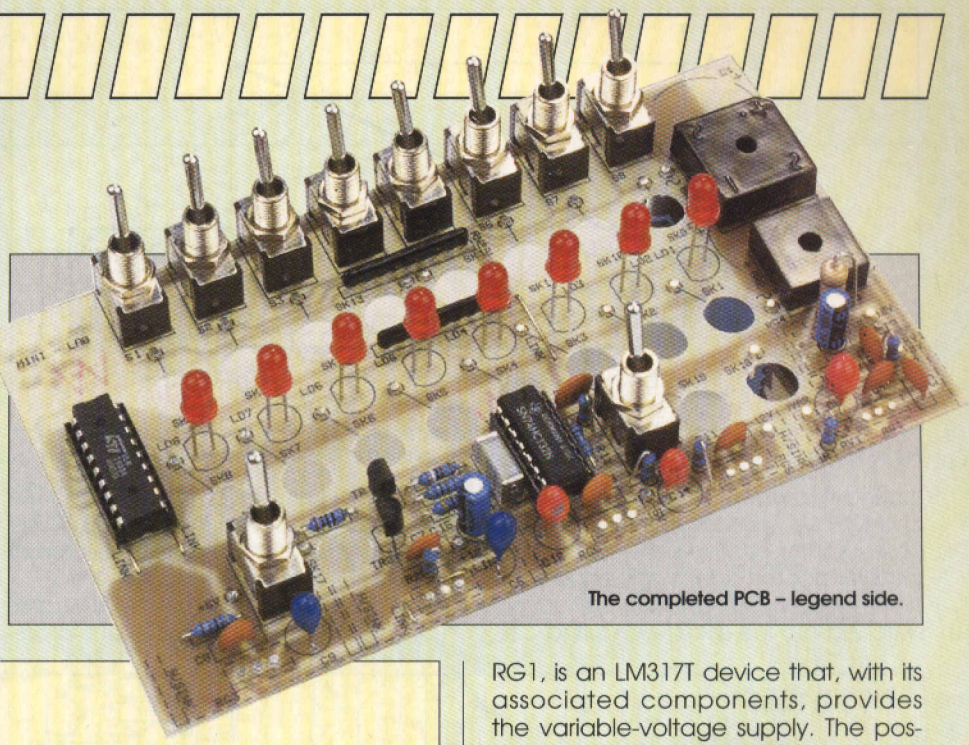
* Education * Project Development * Servicing Analogue and Digital Equipment

The Minilab, shown in block diagram form in Figure 1, is a very useful piece of test equipment, for repairing and developing both digital and analogue circuits alike. Features of the Minilab include fixed DC voltage supplies at ±5V at 500mA continuous (1A peak), ±12V at 500mA continuous (1A peak), and −15V at 100mA continuous (200mA peak). There is also a variable positive voltage DC supply that can be adjusted to give between 1·25V and 24V; the current available from this supply depends upon the output voltage, as seen from the derating graph of Figure 2.

Note, however, that the current drawn by the +5V and +12V rails combined must not exceed a total of 1A – the same comment applies for the –5V and –12V rails.

Other features of the Minilab include eight TTL-level outputs, and eight TTL-level inputs – each fitted with an LED

that indicates a logic 1 ('high') condition when illuminated. There is also a TTL-level oscillator switchable between aproximately 1Hz and 1kHz and, last but not least, a debounced TTL-level 'one-shot' switch with complementary (Q and $\overline{Q}$) outputs, which is very useful for single-stepping through digital circuits that use sequential logic. Debouncing is, as the name suggests, a 'cleaning up' of the switching action – the complementary outputs are always either high or low – nothing else – and at the correct TTL level.



The completed PCB – legend side.

Prototype Specification

Power Supply Voltages :	+5V*, +12V*, +1·25V to 24V Variable (refer to Figure 2 for output characteristic) −5V*, −12V*, −15V (100mA continuous, 200mA peak)
Power Supply Ripple:	less than 5mV per rail
Oscillator Output:	TTL compatible; frequency 1Hz or 1kHz
Octal Logic Input:	TTL compatible; indication by LED (On = High)
Octal Logic Output:	TTL compatible
'One Shot' Switch:	TTL compatible; debounced

* The *total* load on the +5V and +12V supplies must not exceed a peak value of 1A, since the 5V supply is sourced from the +12V supply's regulator (refer to Circuit Description). The same comments apply to the −5V and −12V supplies.

Circuit Description

Most of the circuitry used in the Minilab, shown in Figure 3, is fairly standard. The positive and negative supply rails are derived from a dual-winding transformer via bridge rectifiers BR1 and BR2, and are smoothed by C1 (positive rail) and C2 (negative rail). The unregulated positive rail is then passed to two independent regulators. The first of these, RG1, is an LM317T device that, with its associated components, provides the variable-voltage supply. The positive rail is also passed to RG2, which is a µA78S12UC fixed 12V regulator. Apart from feeding the Minilab's +12V output terminal, RG2 also supplies the µA7805UC +5V regulator RG3. This is done simply because the unregulated supply voltage, i.e. that present at C1, is too high for RG3 (imagine its power dissipation since the regulator would have to drop over 20V at 500mA!) and so the 12V regulator is used – in addition to its primary role of providing the Minilab's somewhat essential 12V output – to drop it down to something more manageable.

The unregulated negative rail from C2 is also passed to two regulators – RG4 (µA7915UC), from which the −15V supply is obtained, and RG5 (µA7912), from which the −12V supply is derived. Note that the third negative power supply rail (−5V) is derived from the −12V regulator, via RG6 (µA7905UC), in the same way (and for the same reasons) as the +5V supply was obtained from the +12V rail.

The 1Hz/1kHz oscillator is based

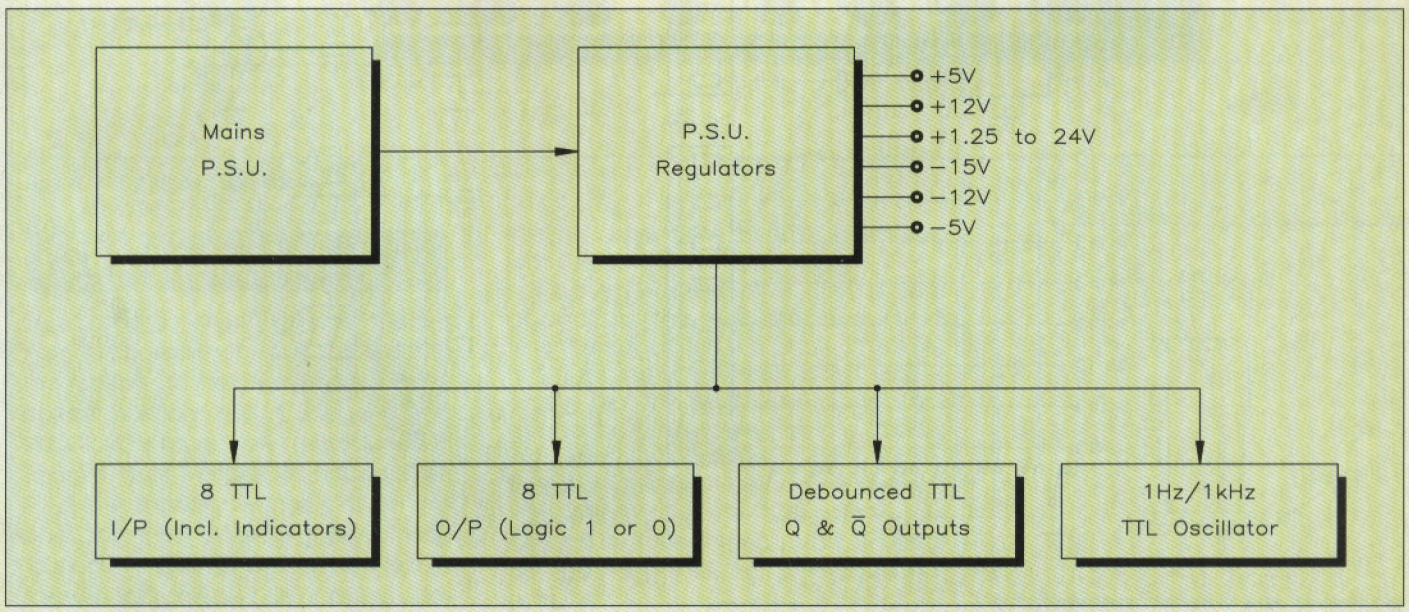


Figure 1. Minilab block diagram.

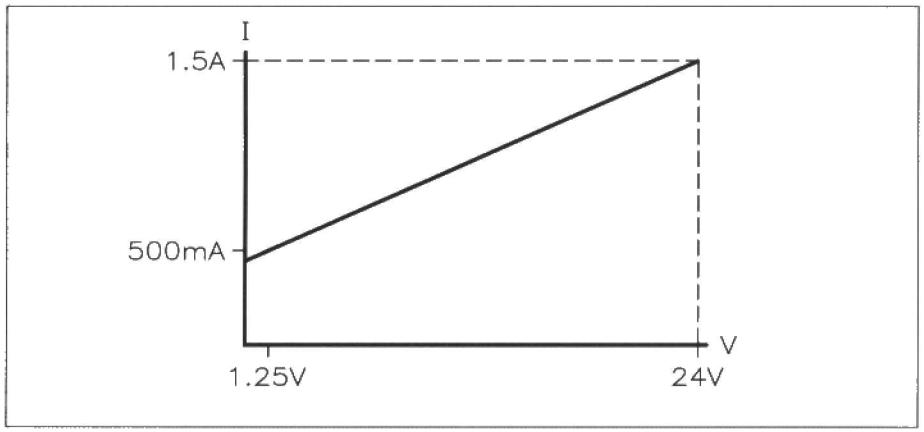


Figure 2. Derating curve of LM317T voltage regulator, as used in Minilab's variable positive supply.

around two of the gates in IC2 – IC2a and IC2b – which are Schmitt NAND gates configured here as an astable multivibrator. The operating frequency is determined by R7, and the capacitors switched into the circuit – C15 and C16 for 1Hz, or just C16 for 1kHz. TR1 and TR2 are used to buffer the output of the oscillator, while maintaining the correct TTL level.

The other two Schmitt NAND gates of IC2 – IC2c and IC2d – are cross-coupled, forming a S-R bistable. This circuit has the effect of debouncing S10, which is responsible for the Minilab's 'one shot' output. Cross-coupling these two gates ensures 'bounce-free' outputs, and that they both switch at the same time.

There are eight TTL-level outputs, the state of which is controlled by S1 to S8. When the switch is open, the pull-up resistor associated with the switch holds the output high; when the switch is closed, the output is forced low. The remaining circuit featured in the Minilab is the octal TTL-level indicator – note that the inputs to each LED are buffered by one of the gates in IC1 (ULN2803 octal Darlington driver) to minimise the chance of loading the circuit under test.

Figure 3. Minilab circuit diagram.

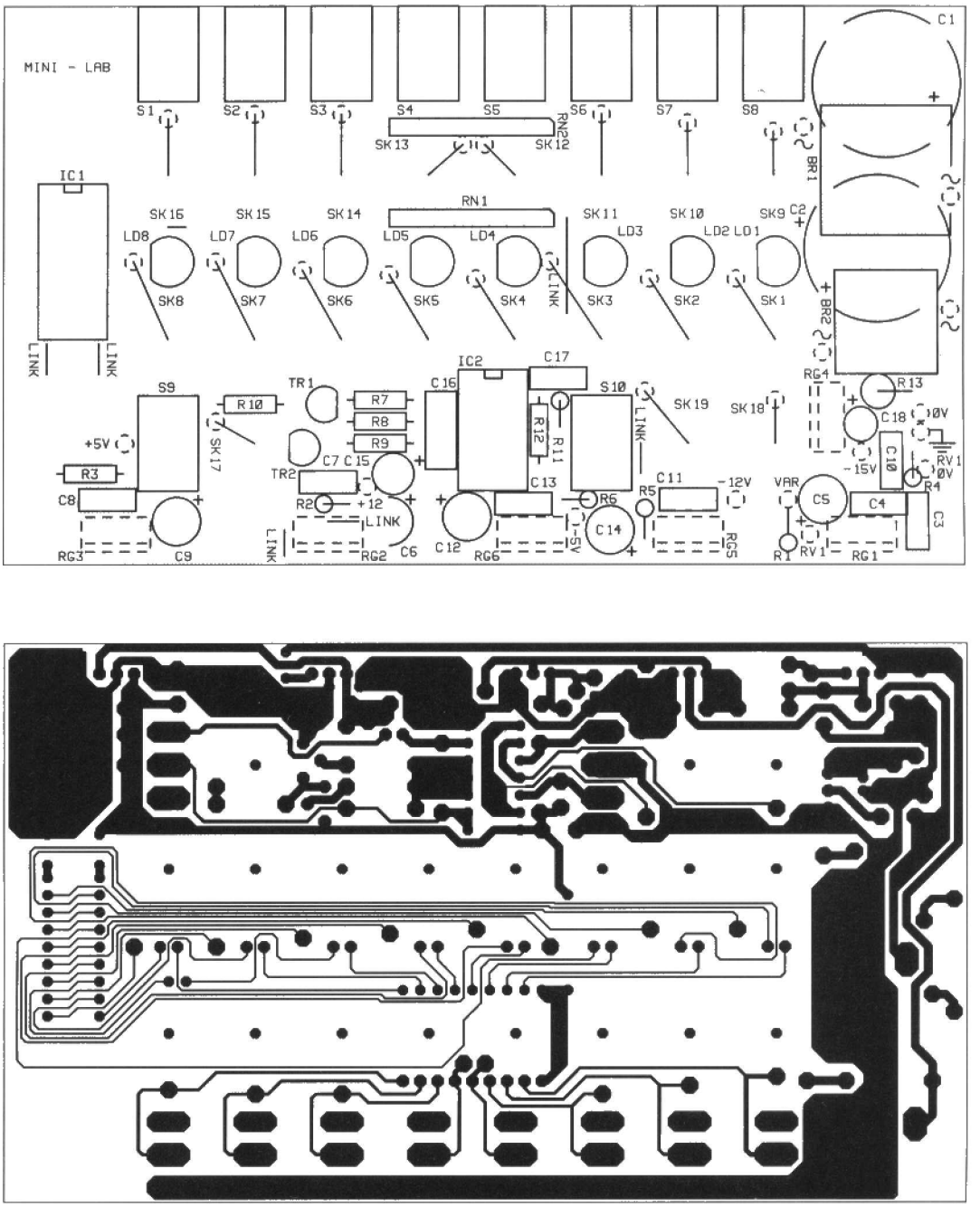


Figure 4. PCB legend and track.

PCB Construction

Begin construction by fitting the PCB pins from the component side, followed by the resistors. To help you locate component positions, the PCB legend and track layout have been reproduced in Figure 4. Note that the SIL resistors (RN1, RN2) are marked with a dot on the package; this must be aligned with the 'cut corner' on the PCB legend. Next, fit the wire links; the off-cuts from the conventional resistors will suffice. Install the IC sockets, aligning the notch of the socket with the notch on the legend.

Fit the 7915 regulator and all the capacitors; the regulator and large reservoir capacitors (C1 and C2) are fitted from the solder side of the PCB – ensure that the electrolytic capacitors are correctly orientated before soldering. Install the rectifiers – making sure that you align the '+' symbol on the rectifier with that on the PCB, prior to soldering it in place. The transistors, TR1 and TR2 (do not get them mixed up!), can now follow.

We now move on to the switches.

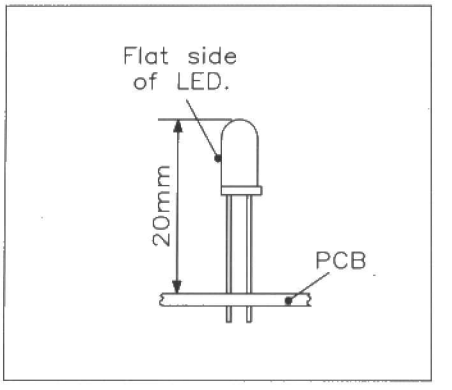


Figure 5. LED mounting details.

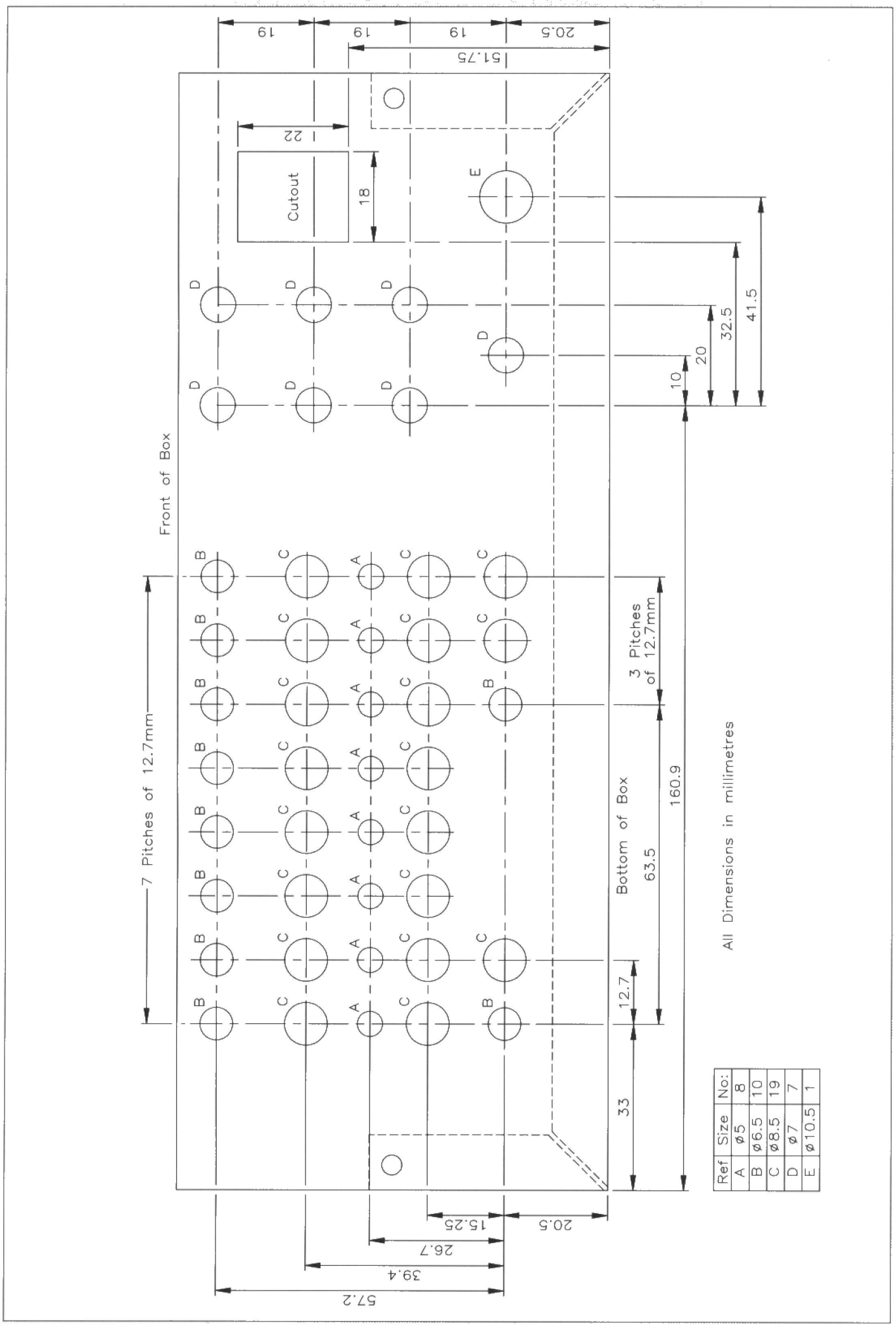


Figure 6. Front panel drilling details.

Before installing these, identify and put to one side the type 'K' toggle switch (this switch has a momentary change-over action) from the type 'E' toggle switches (these have a conventional change-over action). After unscrewing the securing nut and taking off the shakeproof washer, remove the tag location washers from all switches, and discard. The nuts and spring washers, however, should be put to one side. Insert the previously-identified type 'K' toggle switch into the S10 position, with the toggle pointing towards the centre of the PCB. Solder only the centre leg of the switch; check that the switch is squarely positioned – if so, solder the other two legs of the switch.

When S10 has been fitted satisfactorily, install the nine type 'E' switches in the S1 to S9 positions, observing the same precautions. Referring to Figure 5, mount the eight LEDs (LD1 to 8) at a total height of 20mm, aligning the flat side of the LED package with the flat side of the corresponding marking on the PCB legend. Solder only one lead of

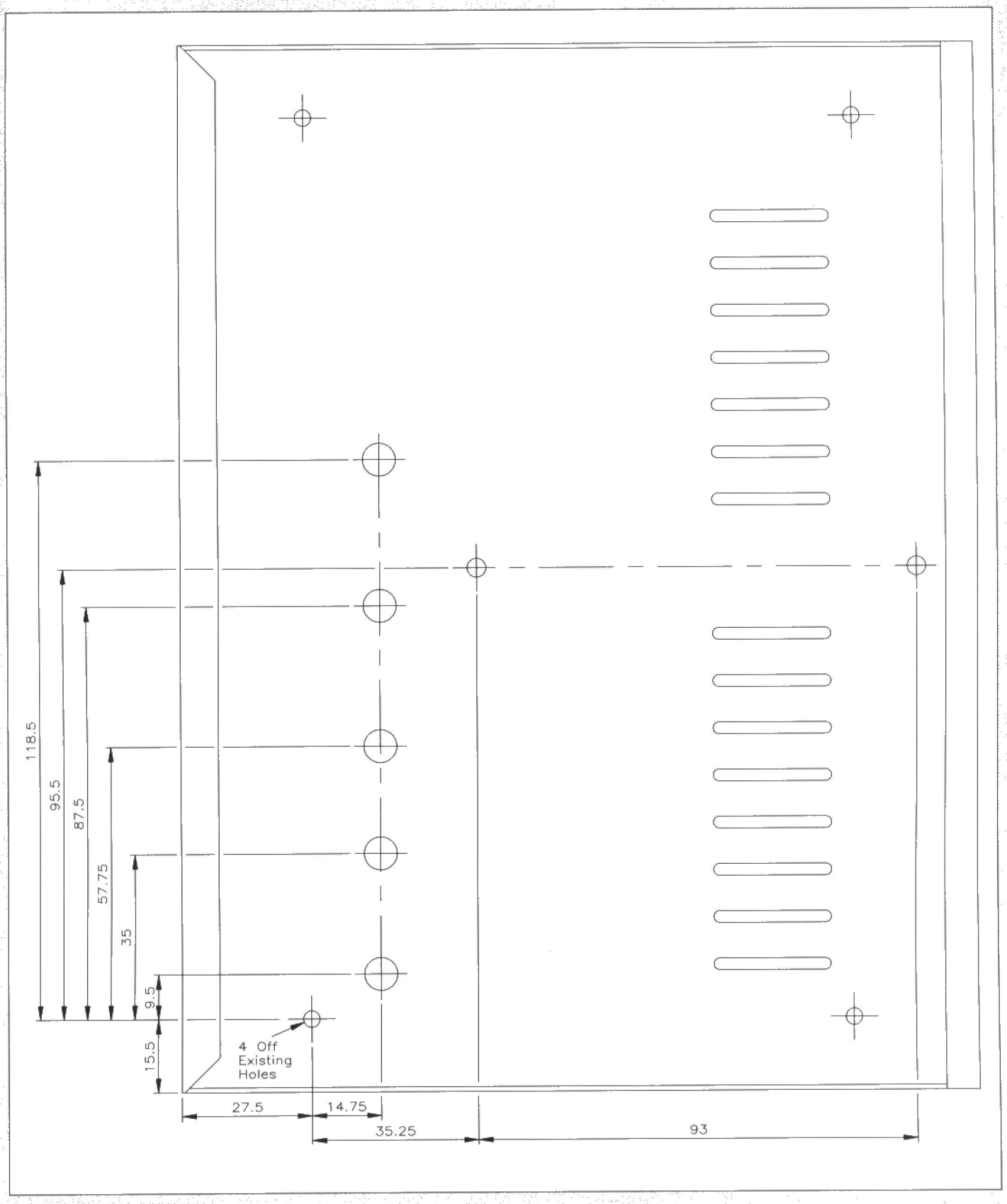


Figure 7. Base drilling details.

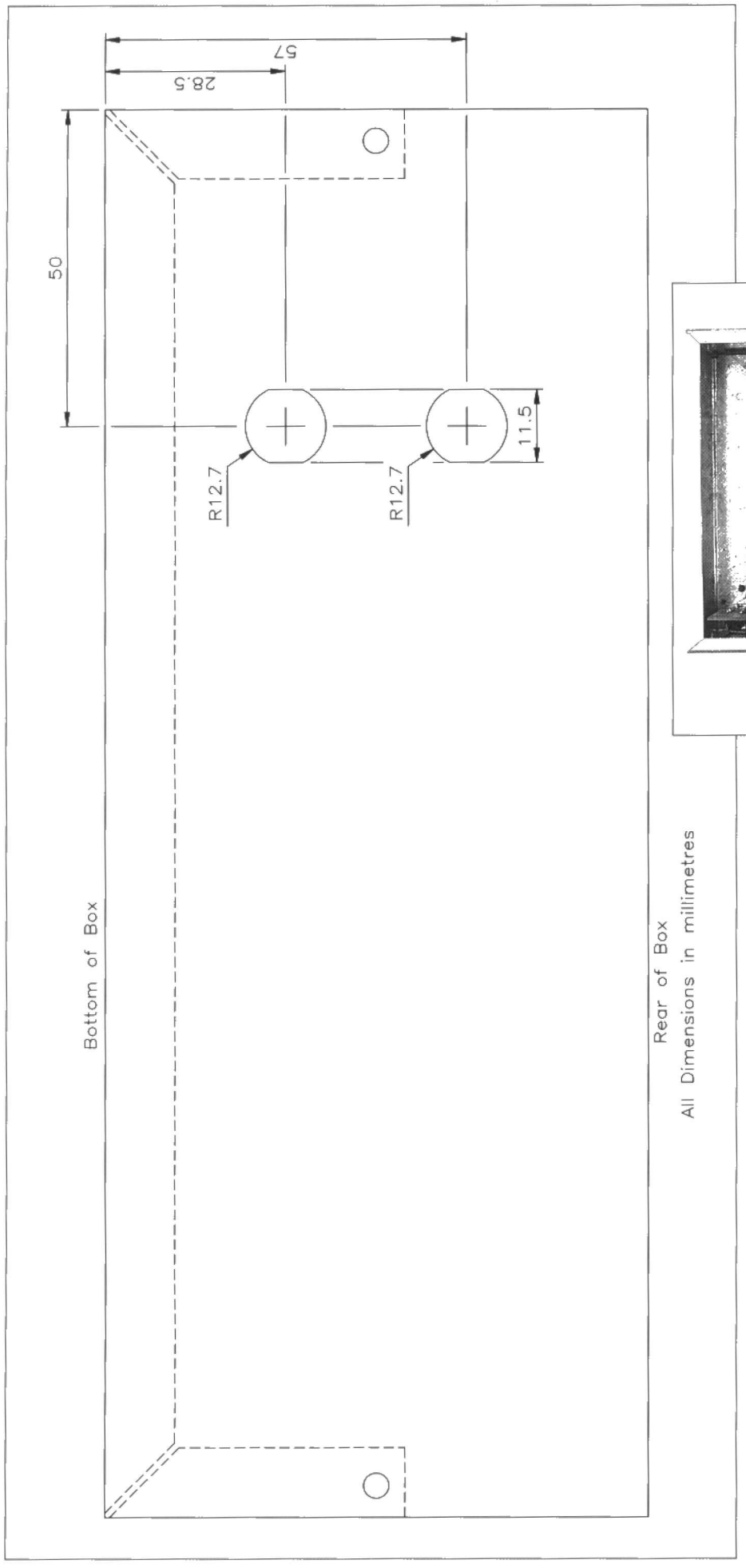
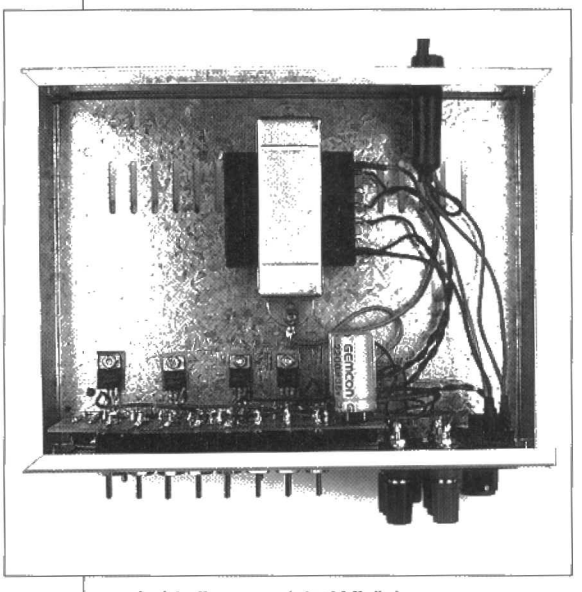


Figure 8. Rear panel drilling details.

the LED initially; if any adjustment is necessary, reflow the solder joint and reposition the lead. When all of the LEDs are installed and have been squarely aligned at the correct height, solder the second lead and crop off the excess.

Finally, fit both ICs into their respective sockets, ensuring correct alignment.

If any points seem unclear, please refer to the Constructors' Guide, included in the kit, for helpful practical guidance.



Inside the completed Minilab.

Box Drilling

Remove the front panel from the box, after having removed the top cover. Cut out, or make a photocopy of, the front panel drilling details given in Figure 6 – this will be used as the template. If you are making a photocopy, check that the drawing's dimensions are preserved – some photocopiers have a nasty habit of introducing enlargement or reduction errors, which may become problematic when it is time to fit the front panel label and controls! Alternatively, the front panel label could be used as a drilling template when the control holes have been cut out. Drill and file out all the holes in the box as shown in Figures 6 (front panel), 7 (base) and 8 (rear). Remove all burrs from the holes.

Final Assembly

Attach the self-adhesive label to the front panel and carefully trim, using a sharp craft knife or scalpel, around the holes through which the controls, indicators and terminals will protrude. The front panel legend is reproduced in Figure 9. Trim the potentiometer spindle down to 9mm, as shown in Figure 10.

Referring to the exploded assembly diagrams of Figures 11 and 12, fit all the 4mm sockets and binding posts. At this stage, do not fit the mains switch or RV1.

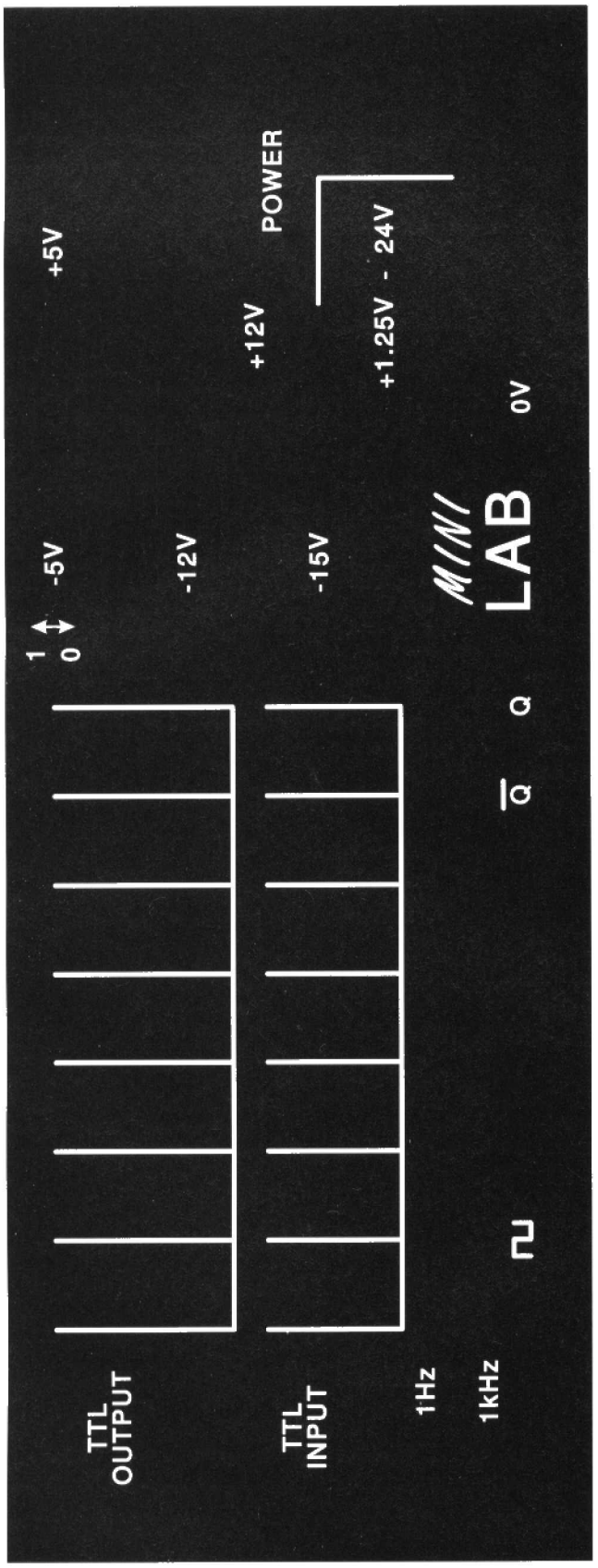


Figure 9. Front panel legend.

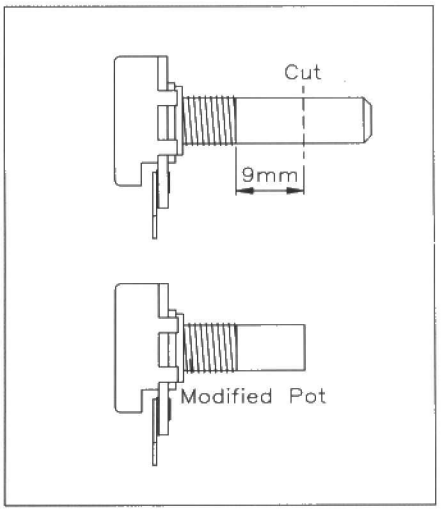


Figure 10. Trimming RV1's spindle.

Looking at the toggle switches mounted on the PCB, each of the position-setting lock-nuts should remain. Adjust the position of these to 4mm from the end of the switch mounting bushes, as shown in Figure 13.

Replace the shakeproof washers, and then fit the front panel over the switches. Lock the panel in place with the securing nuts. The solder buckets of the 4mm sockets should be clearly visible through the corresponding holes in the PCB.

Final Wiring

Referring to the PCB legend, connections to the low voltage and signal-carrying terminals from the relevant pins on the PCB should be made using the tinned copper wire supplied in the kit. The power connections, which are located away from the PCB, must be made with insulated 16/0·2 wire – preferably colour-coded! Binding-post terminals apart, the insulated wiring also includes that from RV1, and the earth (0V) wire that will eventually be connected to the chassis. Figure 14 shows the PCB wiring. Bearing in mind that RV1 has not yet been fitted, ensure that its connecting leads are long enough to allow it to be fitted to the front panel correctly.

Preform the regulator leads as shown in Figure 15, and then loosely install the regulators, together with their associated insulators and bushes, onto the case in the appropriate positions (refer to Figure 11). After fitting the two front panel screws with M2·5 washers (these will prevent the panel label from being damaged), the front panel assembly can be screwed tightly to the box. Line up the regulator leads with their corresponding pins on the PCB, and then tighten their securing screws. The regulator terminals can now be soldered to the pins. Check, using a multimeter set to its highest resistance range, that there is no connection between the tabs of RG1, RG4, RG5 and RG6, and the box. At this stage, RV1 can now be fitted, together with its control knob.

Continued on page 35.

SECURITY ON THE MOVE

by Alan Simpson

Is it a bird? Is it a plane? No, it's the Incident Command Vehicle (ICV) – as used at rock and pop concerts, football matches, and other venues where crowds and trouble could be present.

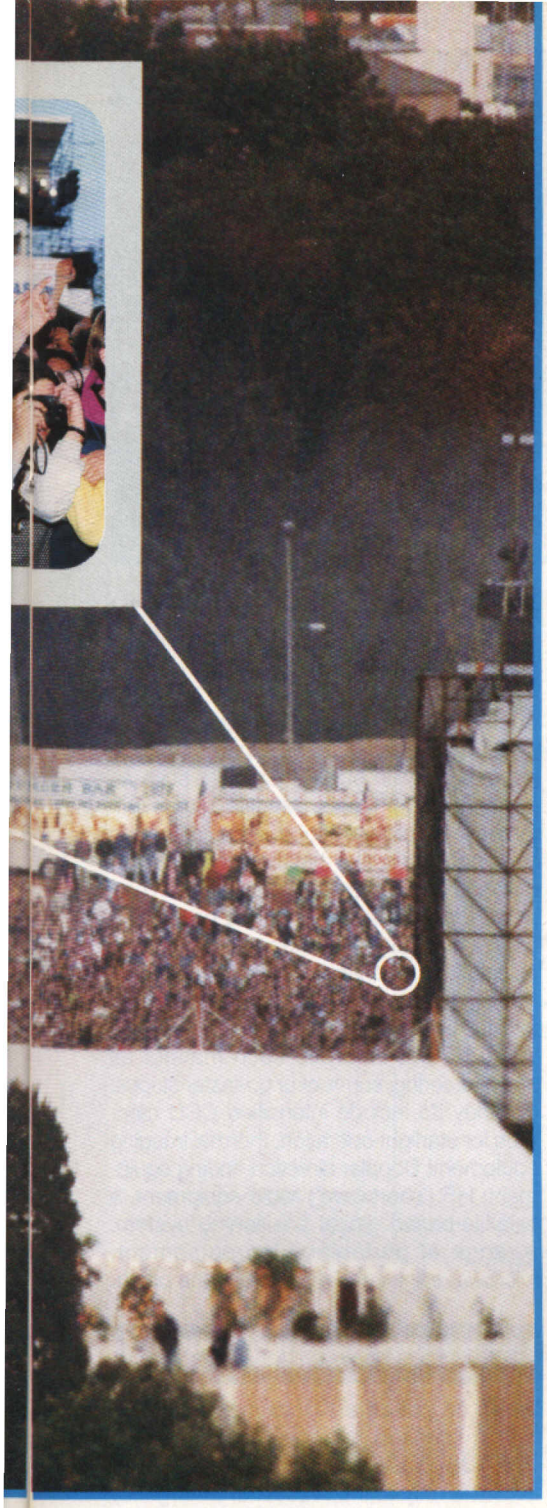
The vehicle, according to its designer, electronic security consultant James McCracken houses a wealth of high technology electronics and communications. Perhaps the only surprising thing about the vehicle is that it did not have a starring role in the film 'Sneakers'. The Incident Command Vehicle provides just about the ultimate in security protection, covering such activity areas as:

* Fast-response, temporary security cover for high-risk areas.
* An overt security centre for protection of visiting VIPs.
* Crowd control at open-air venues, sports events, festivals.
* An industrial hazard control centre.
* Evidence collection during national emergencies and disasters.

"Innovation in electronics", says James, "is shaping the future of the security industry" James McCracken specialises in the design and manufacture of what might be described as the more unusual type of security product and system. These products and systems – indeed, his entire consultancy – is geared to providing a specialist auxiliary service to the security industry. As James comments: "Not to put too fine a point on it, we are one of the most innovative electronic security companies of the 1990s and, because of this, we can (and do) operate on an international basis". His customers include government security services, airport and hospital authorities, armed services, heads of state, and VIPs generally. Not surprisingly, given its electronics background, the company has the ability to plan wide-area networking of civil defence, emergency planning and intelligent disaster warning systems, several of which are already operational in the Middle East. The systems are radio-linked to a secure command centre. In addition to providing high-powered siren warnings, the remote 'emitters' can provide precise verbal instructions to the general public. The electronic systems do not, however, stop at the mere protection of capital assets. By amalgamating such well-proven security aspects as CCTV and perimeter protection, together with a range of other disciplines such as public address, access control, explosives detection equipment, and computerised building management systems, the company can provide a high degree of security and safety management.

Main pic: Scenes at the Glasgow Michael Jackson concert where the ICV was in use.

Right: James McCracken's Incident Command Vehicle.



The Workhorse

Although James McCracken makes use of various types of off-road vehicles, and rebuilds former military vehicles such as the Land Rover 101 and similar all-terrain machines, the company is perhaps renowned for its ICVs. These come as both 4-wheel and 6-wheel drive Stonefield all-terrain trucks. They have unparalleled off-road capability, and are fitted with automatic locking differentials, which ensure maximum traction even over the most adverse ground conditions. ICVs are designed to accommodate a two-man crew, and the bodywork is narrow enough to allow easy access through forests, farm gates and other obstructions. To complete the picture, the interiors are compact, with the apparatus sensibly located so as to provide a comfortable working environment. The vehicles also sport hand-basins and adequate refreshment facilities (essential to while away the hours of vigilance!). Privacy and anonymity is assured by double-glazed tinted windows. Provision of power has not been left to chance – if a 240V AC landline connection is not available, the vehicle can adequately supply its own power requirements; fitted are an engine-driven generator, a 3kW electric-start generator, and a DC to mains-voltage inverter. The vehicle should also be clearly visible, since xenon flashing road beacons can be fitted with different lenses depending on the applications – amber for airport use, green for medical use, and blue for emergency use. In addition to normal-wavelength outside lights, the unit is fitted with infra-red lights, mounted on stalks for close work – these augment the night-vision cameras.

Communications Centre

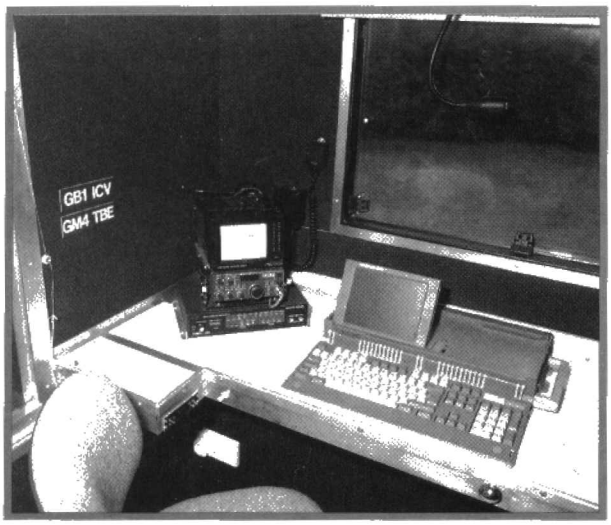
On-board communications equipment includes a general coverage VHF transceiver with full coverage from 138 to 174MHz, a Band III national-coverage trunk-route VHF transceiver (designed to keep the ICV in contact with the nearest Crime Prevention HQ), plus a 25W base station and 4 matching hand-held pocket radios fitted as standard. Other radio communications equipment includes a marine-band transceiver and air-band receiver. A mobile phone, which is connected to both Cellnet and Vodafone networks, enables the operator to connect to the public telephone system. Just in case you were wondering – yes, the vehicle *does* have a scrambler! The Racal encryption/decryption units ensure a secure comms link from the ICV to a remote destination. A Group 3 fax/copier is fitted – this can be used over the Vodafone network.

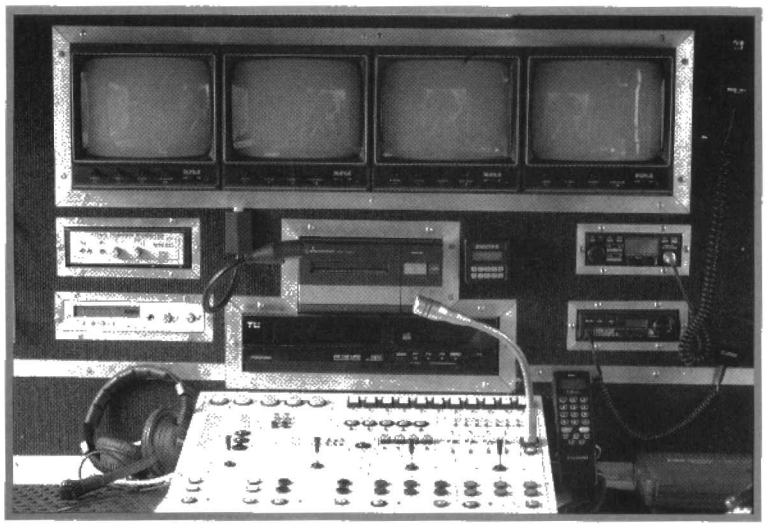
Emergency Network

Since its VHF radio equipment covers the 2 metre 'ham' allocation, the vehicle can link into RAYNET – the radio amateurs' emergency network – the use of which can be legally requested by any public emergency service during disaster situations, or to provide enhanced communications for other specialist purposes. Such help is normally requested by emergency planning officers, coastguards, police, fire or ambulance services. Facilities for Paknet packet radio are also provided. More on-board security is provided by means of an eight-channel security centre which is fitted to the control console. This allows the operator to monitor remote locations in a high-risk security application. These could be, for example, VIP vehicles, aircraft, Portakabins, or even radio-

Top: ICV with pneumatic mast raised. Mounted at the top of this mast are lighting equipment and cameras – the extra height is used to its greatest advantage when surveying crowds.

Above: Interior view of ICV – how do they fit it all in?





operated personal attack buttons carried by security staff engaged in the exercise. Operators of the outlying radio units will not only announce the security breach to the ICV operator, but will also communicate the same information to Crime Prevention HQ, using packet radio, normally within 3 seconds.

Vision On

The main operating console to the rear of the vehicle is used to control four CCD cameras (two colour, two infra-red monochrome). The rearmost cameras are mounted on two pneumatic masts that can be raised some 8m above the ground. All the cameras are fitted with powerful 10:1 zoom lenses, and each camera has its own dedicated pan-tilt unit operated from the console using a joystick control. There is a dedicated 'preview' monitor, allowing all four images to be viewed simultaneously. Any of the cameras can also be routed to either of two video cassette recorders, while a video printer is provided to enable a hard-copy of any particular frame to be produced where required. Meanwhile, a 25W colour TV transmitter can relay the selected CCTV picture to a remote security overseer several kilometres away.

Among the other facilities available is a 200W public address amplifier which can be used for public order or crowd control. In addition to the console operator's microphones, two radio-mikes may be used from a distance of up to 500m from the vehicle. As James McCracken says, "this is a useful facility for stewards at open-air festivals to avert potentially dangerous situations developing."

Top left: One of the IBM PCs together with the packet radio equipment.
Top right: CCTV equipment on board the ICV. Note the large camera control panel.
Above: ICV – ready for action!

Those remote radio operators can soon be summoned 'back to base' at the first hint of rain. The vehicle has a built-in weather-station – a simple yet effective system that will indicate wind speed/direction and outside temperatures. The weather-station is essential when both masts are fully extended (having a large surface area, these are subject to wind loading), or when used at chemical-related incidents where wind-direction information is crucial.

On-board Computers

Each security vehicle is equipped with two IBM-compatible PCs. These are not provided for playing games, but to allow the user and Emergency Planning Officers access to a database containing important information. Each PC has a 386 processor, 4Mb RAM and 80Mb hard disk, and is fitted with a modem card to allow access to the cellular telephone network. Ancillary equipment includes a bubblejet printer, while software includes DBase 3 and road-travel planner Autoroute. Should the pop concert overrun, don't worry about the vehicle occupants. Each truck boasts two 12V kettles, 10 gallons of fresh drinking water, a 10 gallon waste water container, and a stainless steel sink. While relaxing, the occupants can also get to grips with other equipment such as portable searchlights, Maglite aluminium torches, emergency food, Aldis signalling lamp and flares. Not that they need venture out too much. Each vehicle is fitted with carpeted walls and ceiling, blinds on all windows, binoculars, compass and a large selection of Ordnance Survey maps. But, like all vehicles, there is a range of optional extras. In the case of the ICV, however, these do not embrace such matters as power steering, sun-roof or go-faster stripes. But they do include intensified CCD cameras for starlight operation, thermal imaging equipment; Doppler direction-finding equipment; HF ('shortwave') radio equipment, a satellite-based global positioning system, a range of portable video equipment, microwave links and a BT telephone patch.

It's an Emergency

When on call, the ICV comes complete with a licensed radio operator (callsign GM4TBE). The RAYNET facility, however, is available only at the request of Emergency Planning Officers, police, coastguards or optional services.

A Maplin Connection?

Out of interest, a significant proportion of the on-board equipment is sourced from Maplin – particularly in the communications area. In fact, as James McCracken confirms, "We have largely bought 'off-the-shelf' items from local Maplin shops, or using the MPS mail order service". So if you have an idle hour or two, plus a reasonable credit account with Maplin, perhaps you can start converting your spaced-out Peugeot 205 now. But if you are shopping for the ready-made item, perhaps to impress the neighbours or take your loved one to the local disco, then contacting James McCracken seems eminently sensible. There are practically no limits to what can be achieved; in James' words, "if you can imagine it, we can design it, build it and get it on the road."

Minilab continued from page 31.

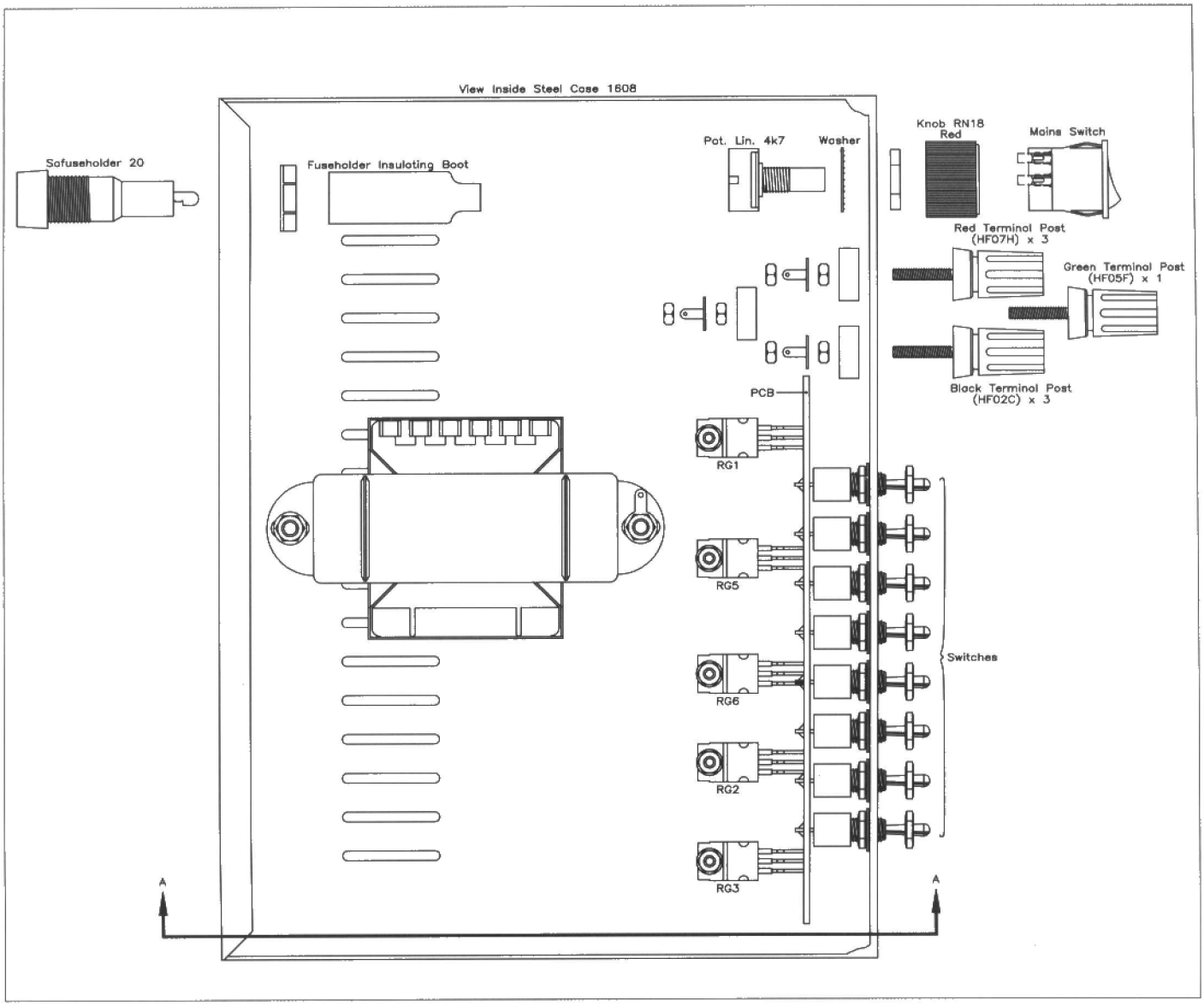


Figure 11. Exploded assembly diagram (top view).

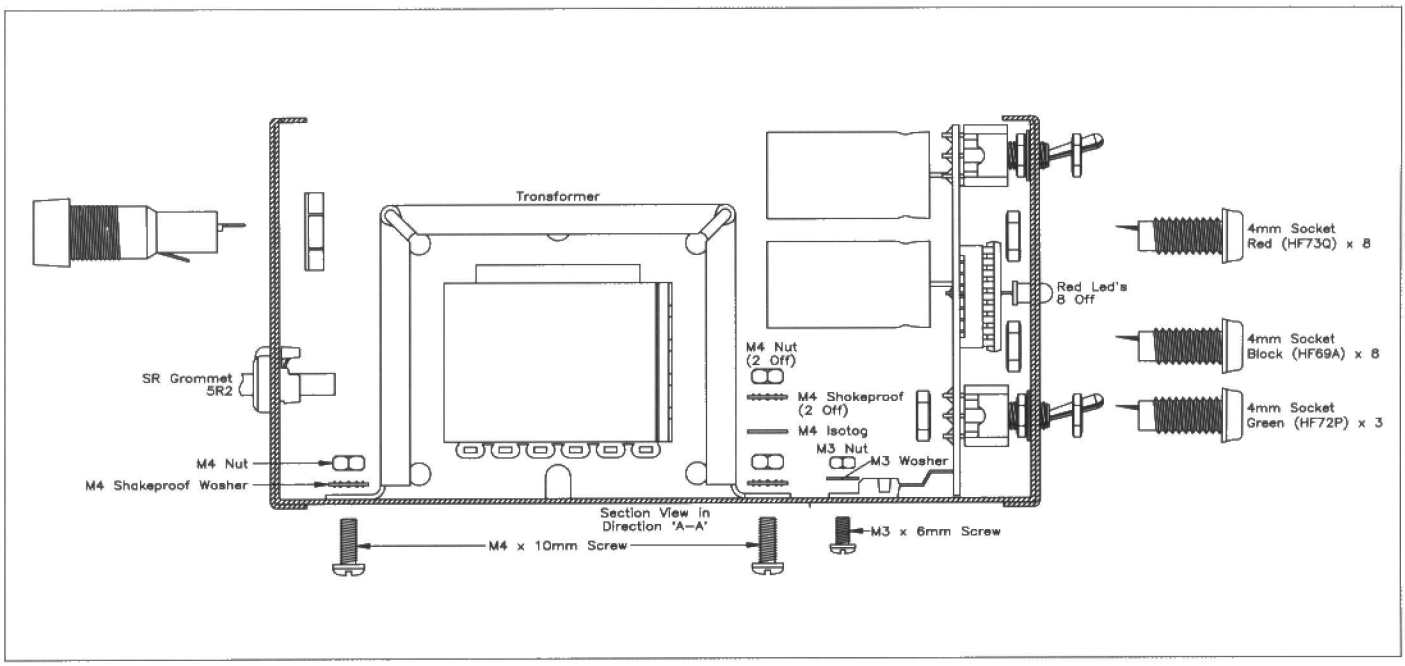


Figure 12. Exploded assembly diagram (side view).

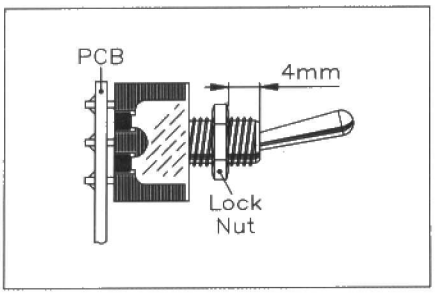


Figure 13. Prealigning toggle switch lock-nuts.

The mains switch can now be fitted; note that the outer contacts of the latter should be closest to the edge of the panel. Install the fuse holder and mains cable to the rear panel – note that the mains cable should be fitted with a strain-relief grommet. Wire up the fuse holder and mains switch as shown in Figure 16 – do not forget to cover the fuse holder with its purpose-designed insulating boot. The mains switch contacts should also be insulated, using heatshrink sleeving. Fix the transformer to the bottom of the case, using M4 mounting hardware as shown in Figure 12, remembering to include the earth tag. Wire up the switch to the transformer, insulating the exposed wiring with heatshrink sleeving. Solder the earth wire from the mains lead, together with the one previously soldered to the PCB, to the transformer earthing tag. Wire up the secondary of the transformer to the PCB pins as shown in Figure 14, and finally install the 20mm fuse into the fuse holder.

Your Minilab is now complete – all that is left to do is to screw the top of the case into position, and to fit a 13A plug (with 2A fuse) to the mains lead. Before assembling the case, however, a thor-

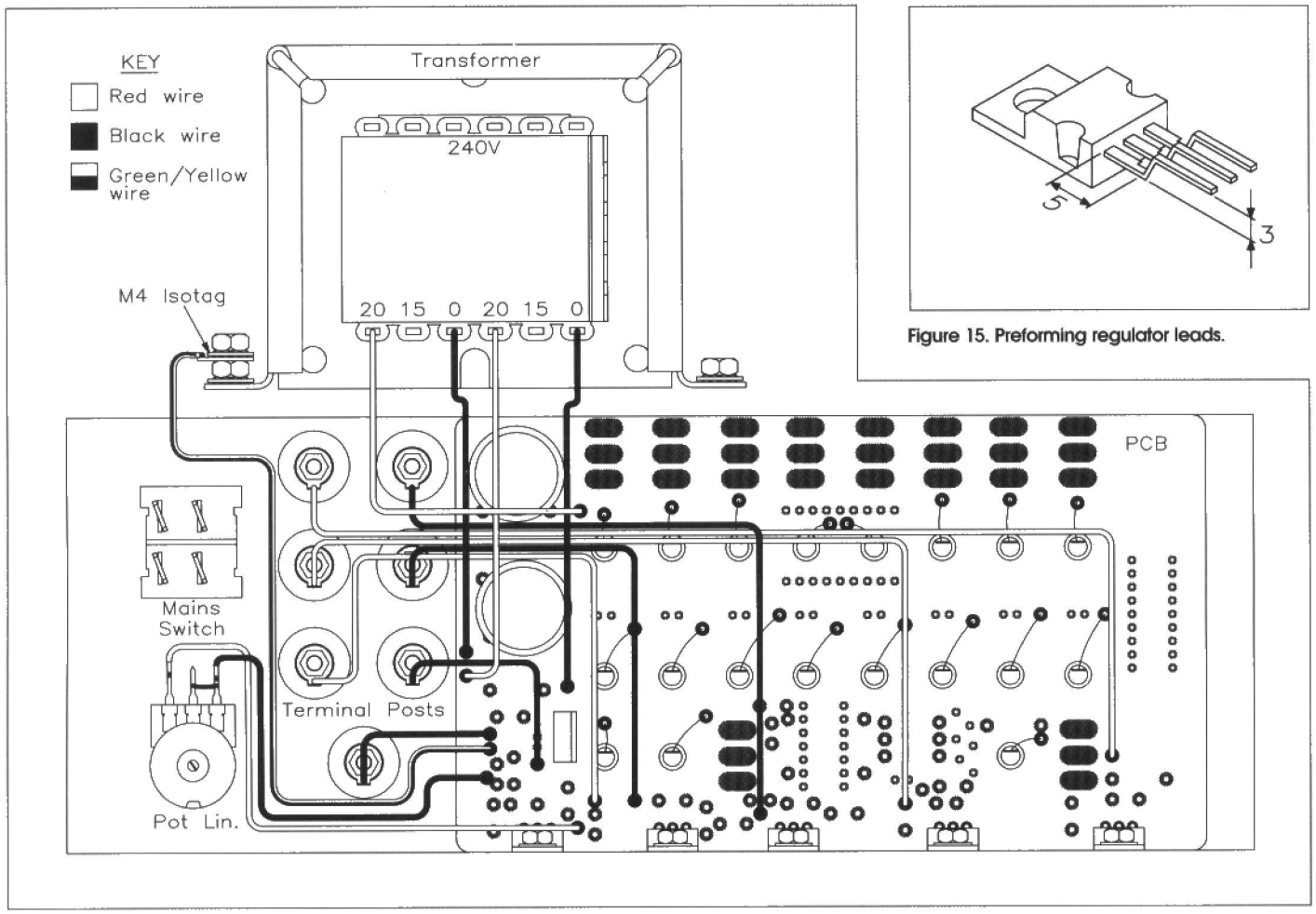


Figure 14. PCB wiring diagram.

Figure 15. Preforming regulator leads.

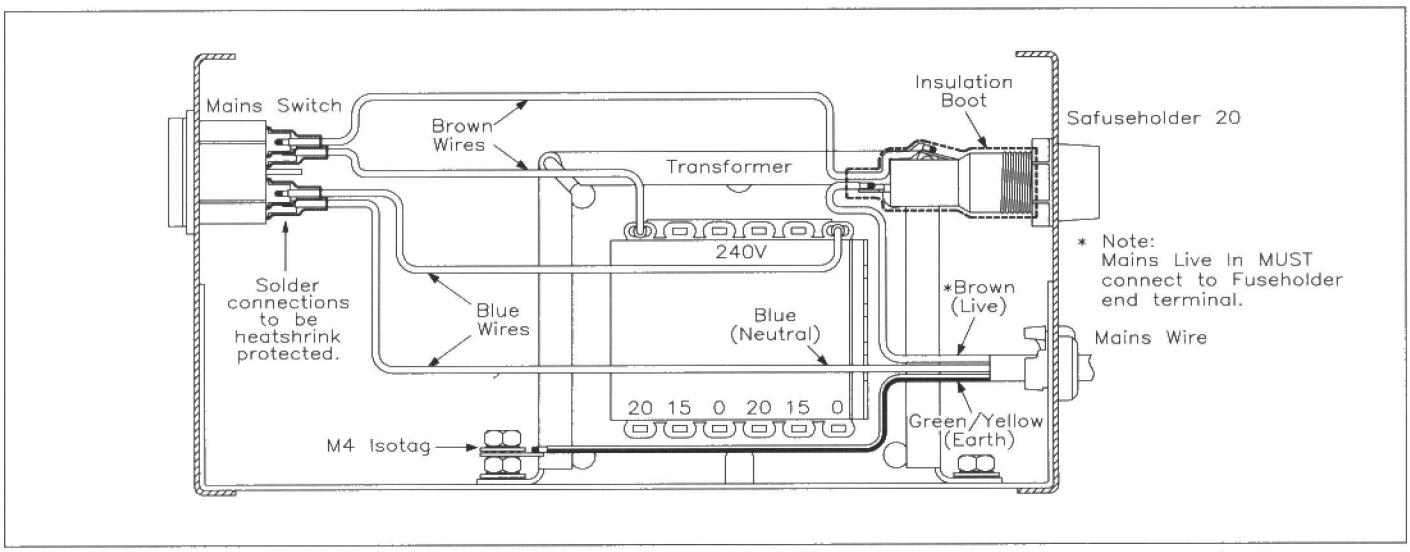


Figure 16. Mains wiring diagram.

ough check of your work is recommended – a little time spent doing this may save much, much time later. As the old saying goes, 'a stitch in time saves nine!'

Testing

It is imperative that every possible precaution is taken to prevent electric shock. 240V AC mains can kill. DO NOT connect the Minilab to the mains until the instructions say to do so.

With the Minilab's mains switch set to 'on', measure the resistance between the 'live' and 'neutral' pins of the mains inlet plug; it should lie in the range 10Ω to 100Ω. Measure the resistance between the 'earth' pin and various parts of the case metalwork; a value of ≤100mΩ is expected in each case. Measure the resistance between the 'live' and 'earth' pins, and between the 'neutral' and 'earth' pins. In both cases, the reading should be infinity. If a 'Megger' type test meter is available, repeat the last test; the reading should not be less than 2MΩ at 500V.

Plug in the Minilab and switch on. The rocker switch should illuminate, but all of the LEDs should remain unlit. Connect the first TTL input to the TTL output located directly above it on the control panel – the LED should glow if the relevant switch is in the up ('1') position, but should remain off if the switch is in the down ('0') position. Repeat this test for the other seven input/output pairs. Next, connect the oscillator output to one of the TTL inputs – the LED should flash when the oscillator switch is set to its 1Hz position, and appear to be continuously illuminated when set to 1kHz. When the Q & $\overline{Q}$ outputs are connected to two of the TTL inputs, the LED connected to the $\overline{Q}$ output should illuminate, while the other should remain unlit. When the Q/$\overline{Q}$ switch is held down, the reverse should happen; the LEDs will revert to the original condition when the toggle switch is released.

Using a multimeter, check that the correct output voltages are present on the binding post terminals, and that the variable output delivers between 1·25V and 24V.

Your Minilab has now been fully tested and is ready for use.

MINILAB PARTS LIST

RESISTORS: All 1% Metal Film (Unless specified)			
R1	240Ω	1	(M240R)
R2,3,4,5,8,9	4k7	6	(M4K7)
R6	2k7	1	(M2K7)
R7	3k9	1	(M3K9)
R10	100Ω	1	(M100R)
R11,12	1k	2	(M1K)
R13	1W Res 68Ω	1	(C68R)
RN1	SIL Resistor 220Ω	1	(RA24B)
RN2	SIL Resistor 1k	1	(RA27E)
RV1	Pot Lin 4k7	1	(FW01B)
CAPACITORS			
C1,2	2200µF 63V PC Electrolytic	2	(JL29G)
C3,4,7,8, 10,11,13,17	100nF 50V Disc Ceramic	8	(BX03D)
C5,6,9,12,14	10µF 35V Tantalum	5	(WW70M)
C15	100µF 10V PC Electrolytic	1	(FF10L)
C16	120nF Poly Layer	1	(WW42V)
C18	1µF 100V PC Electrolytic	1	(FF01B)
SEMICONDUCTORS			
RG1	LM317T	1	(UF27E)
RG2	µA78S12UC	1	(UJ56L)
RG3	µA7805UC	1	(QL31J)
RG4	µA7915UC	1	(QL36P)
RG5	µA7912UC	1	(WQ93B)
RG6	µA7905UC	1	(WQ92A)
BR1	PW01	1	(WQ57M)
IC1	ULN2803A	1	(QY79L)
IC2	74HC132	1	(UB29G)
TR1	BC559	1	(QQ18U)
TR2	BC549	1	(QQ15R)
LD1-8	5mm Red LED	8	(WL27E)
BR2	S005	1	(QL09K)
MISCELLANEOUS			
S1-9	Sub-Min Toggle A	9	(FH00A)
S10	Sub-Min Toggle J	1	(FF70M)
SK1-8	Socket 4mm Black	8	(HF69A)
SK9-16	Socket 4mm Red	8	(HF73Q)
SK17-19	Socket 4mm Green	3	(HF72P)
	Large Term Post Green	1	(HF05F)
	Large Term Post Red	3	(HF07H)
	Large Term Post Black	3	(HF02C)
S11	Neon Switch Red	1	(KU99H)
T1	Tr 20V 1A	1	(WB12N)
FS1	Fuse A/S 500mA	1	(WR18U)
	Safuseholder 20	1	(RX96E)
	Fuseholder Boot	1	(FT35Q)
	Heat Shrink CP64	1m	(BF90X)
	Heat Shrink CP32	1m	(BF88V)
	Pin 2145	1 Pkt	(FL24B)
	Insulator TO220	5	(QY45Y)
	Plastic Bush TO66	1 Pkt	(JR78K)
	DIL Socket 14-pin	1	(BL18U)
	DIL Socket 18-pin	1	(HQ76H)
	Steel Screw M3 x 6mm	1 Pkt	(JY21X)
	Steel Nut M3	1 Pkt	(JD61R)
	Steel Screw M4 x 10mm	1 Pkt	(JY14Q)
	Steel Nut M4	1 Pkt	(JD60Q)
	Isoshake M4	1 Pkt	(BF43W)
	Isotag M4	1 Pkt	(LR63T)
	Steel Washer M2·5	1 Pkt	(JD77J)
	Wire TC 0·71mm 22swg	1 Reel	(BL14Q)
	Wire 16/0·2 10m Red	1	(FA33L)
	Wire 16/0·2 10m Black	1	(FA26D)
	Wire 16/0·2 10m Green	1	(FA29G)
	Min Mains Black	2m	(XR01B)
	SR Grommet 5R2	1	(LR48C)
	Knob RN18 Red	1	(FD67X)
	Front Panel	1	(DH85G)
	PCB	1	(GH34M)
	Instruction Leaflet	1	(XU18U)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	Steel Case 1608	1	(XJ28F)
	13A Plug Nylon	1	(RW67X)
	Plug Fuse 2A	1	(HQ31J)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As LT26D (Maplin Minilab) Price £49.95

Please Note: Where 'package' quantities are stated in the Parts List (e.g. packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit. The following new items (which are included in the kit) are also available separately, but are not shown in the 1993 Maplin Catalogue.

Minilab Front Panel **Order As DH85G Price £1.45**

Minilab PCB **Order As GH34M Price £3.95**

Stray Signals

by Point Contact

Last year PC attended a one day seminar, given by one of the larger semiconductor manufacturers, at a hotel in Swindon. Mrs PC went too, dropping her husband off at the hotel, and spending the day exploring some of the surrounding countryside – an area which neither of us knew well, despite PC having spent a year stationed at No. 2 Radio School Yatesbury, many years ago. So we decided later in the year to take a short holiday, and view the town and surrounding countryside in more detail. We therefore booked up one of the excellent value half-board breaks 'five days for the price of three', offered by one of the large hotel chains, and set about exploring. Prehistoric Avebury, Benedictine Prinknash with its pottery, the source of the Thames; we saw them all and much more besides. Several times when leaving the town in a northerly direction, we found ourselves negotiating the notorious 'Magic Roundabout'. No, this is not a sweet shop run by Dougall and Florence, or even a local nickname, but the official name for what can only be described as a challenge for the average motorist, and a nightmare for the faint-hearted. At the confluence of about half a dozen roads, a large roundabout is surrounded by as many small ones, and one can negotiate these one by one, or cut through the Gordian knot and go round the large one. I never found out whether the road space around the central roundabout is two way or clockwise only – there is nothing to tell you – and in fact I have never met anyone who wasn't completely mystified by the whole affair on first encounter.

Interestingly enough, not a million miles away from the Editorial Offices of your favourite electronics magazine, there is a very similar roundabout. It's at the busy intersection of the A13 (one of the busiest roads in Essex, leading straight into the heart of the City of London) and the A130 (running between the infamous Canvey Island and the County town of Chelmsford). Although officially known as the Saddler's Farm Roundabout, it too is referred to by locals as the Magic Roundabout. When approaching the roundabout, it is simply a matter of deciding whether to go clockwise or anti-clockwise – because of the layout, you can even change your mind halfway round! Confused? You will be!

We reserved looking around Swindon on foot, until the morning of the day we left. After a visit to the new and architecturally uninteresting shopping centre, we proceeded to the Railway Museum, a visit to which is a must – not just for the locomotives and associated equipment, but for the whole railway town and particularly the restored turn of the century stone-built railway worker's cottage. Walking back to the hotel, to pick up the car, we called in at what was obviously, from its very appearance, a long-established ironmongery and hardware shop, which we had seen across the street from our breakfast table each morning. Take my advice and never simply pass by such a place – we had no particular purchase in mind, but you never know. As it happened, we saw on display a selection of wine glasses. One happened to be the same pattern as a set of six we were given as a silver wedding present, of which only five remained intact, we could not contact the manufacturer because we hadn't kept the box. Naturally we snapped it up, together with two others, the last of their stock of that pattern they had in the stock-room.

Those of you who have read all of these columns, if anyone (Yep, I have! – Ed.), will know about Charlie, the helpful proprietor of a local radio shop in the days of my youth. Like many others of his generation, he had moved into radio from a mechanical background, having originally been apprenticed to a manufacturer of motor lorries, somewhere up north. He hadn't been there more than a week or two before he was asked to deliver a lorry to a customer many miles away. He pointed out that he couldn't drive, only to be told to drive it round the yard a couple of times to get the hang of it, and then get on with it – no such thing as a driving test in those bygone days! During subsequent years he got the hang of all sorts of things, even making motor cars, with a friend. Thereby hangs a tale; for another time perhaps. By the time I used to frequent his radio shop on a Saturday morning – it became a sort of informal radio club – he had long since 'got the hang of radios', and one of his sons was a TV aerial rigger whilst another manufactured car batteries in a shed behind for sale in the shop. Charlie knew all the tricks of the trade but earnestly insisted that he did not use some of the more devious ones. One of these, he related, concerned dealing with customers who brought in a mains superhet table radio (probably bought long before the Second World War) complaining that it no longer received lots of stations on short wave like it used to – in those days people liked to pan around the dial and hear shortwave broadcast stations from across the world, especially Australia. Of course, after a number of years, the mutual conductance of all the valves had fallen off markedly, but this was no problem when receiving Long or Medium Wave stations. But the dynamic resistance of the tuned circuits was much lower on Short Wave, being naturally (with variable capacitance tuning) worst at the bottom-end of each band. Apart from checking the alignment of padders, trimmers and IFs, the only real cure was complete revalving, an expensive business with five valves to replace at about 17s. 6d. (87½p) each. The sharper sort of radio dealer would charge for doing just this whilst in reality replacing just one or two. The rest of the treatment consisted of raising the value of the grid leak in the triode local oscillator section of the frequency changer, from 10kΩ to 100kΩ or more. This made no difference on LW and MW, but on SW, the local oscillator squegged, producing a comb of frequencies at about 150kHz intervals. Now, the set appeared positively alive with stations on short wave, as each station came in at dozens of points along the band. Any subsequent query from the puzzled customer was greeted with the explanation that stations had to broadcast on several different frequencies now-a-days, owing to the Russian jamming.

Yours sincerely

Point Contact

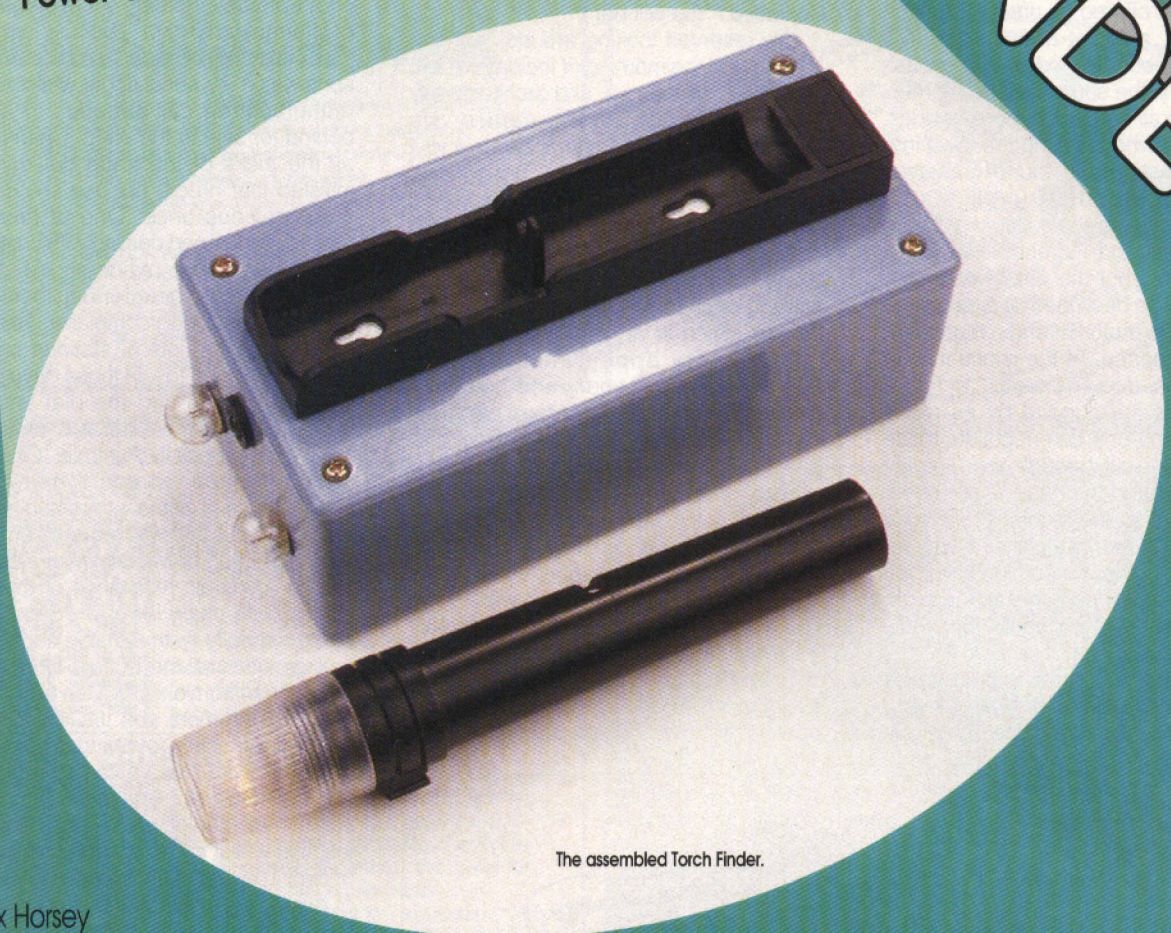
TORCH FINDER

FEATURES

* Lights On when Mains Power Supply Fails
* Recharges Internal Ni-Cd Batteries when Mains Supply Present
* Torch Mounted on Body for Easy Location

APPLICATIONS

* Locating and Replacing Blown Fuses at Night
* Remote Areas with Unreliable Power Supply
* Power Cuts



The assembled Torch Finder.

2 PROJECT RATING

by Max Horsey

A sudden mains power cut, particularly one that extinguishes all the street lamps, can be at best frightening, and at worst the cause of accidents as people fumble around for torches or candles. Many public buildings have battery-operated lights that switch on automatically during such a cut. The project described causes two torch bulbs to light, guiding you to a small clip-on torch also housed on the project. The light produced by the bulbs, though small, is more than sufficient as a temporary measure. An internal rechargeable battery is kept 'topped up' when the mains supply is on, and provision is made to connect a rechargeable torch to the project if preferred, instead of the 'emergency' type employed in the prototype. The circuit is connected to the mains via an inexpensive mains adaptor. Any voltage from 9V to 18V is suitable, and an unregulated adaptor is adequate. Note, however, that the adaptor must be left permanently connected to the mains; some of the cheapest types are for intermittent use only. A green LED indicates that the mains supply is connected, and operation of the torch bulbs during a power cut is fully automatic.

Circuit Description

The block diagram of Figure 1 shows how the 12V supply from the power adaptor is used to light LD1, charge the batteries, and trigger the 'sensing circuit' to prevent the torch bulbs from lighting.

When mains failure occurs the LED stops working, and the sensing circuit causes the torch bulbs to light, power being supplied by the internal rechargeable cells.

Referring to the circuit diagram of Figure 2, it can be seen that the DC supply from the mains adaptor is decoupled by C1, a 100µF 25V capacitor. Capacitor C2 removes any spikes on the supply, and resistor R1 maintains a steady flow of current so that C1, and similar capacitors in the mains adaptor, discharge when mains power is removed. This promotes a rapid switch on of the torch bulbs when a power cut occurs. Indicator LD1 is supplied by current-limiting resistor R2.

IC1 is a 78L05 regulator. Figure 3 shows how such a regulator can be connected to form a current regulator. Resistor R3 sets the output current, about 14mA in this case. This current is independent of the supply voltage provided it is within the range specified.

Returning to Figure 2, D1 provides a bypass path to ensure that the voltage at the output

of IC1 can never be much greater than the voltage at its input. Such a condition would destroy the IC. D3 allows current to flow into the rechargeable cells within the project, but prevents current flowing back to the IC during a power cut. D2 provides a similar path for the cells in the optional rechargeable torch. D2 may be omitted if preferred if a normal torch is employed.

The rechargeable Ni-Cd cells provide about 2·4V across the remainder of the circuit. Transistors TR1 and TR2 form a PNP Darlington pair, which is switched off when the base of TR1 is positive. The 'sensing' point (shown as 'x' on

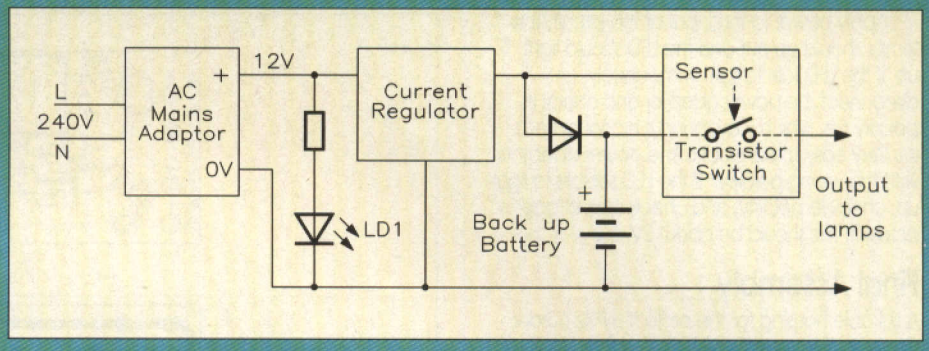


Figure 1. Block diagram.

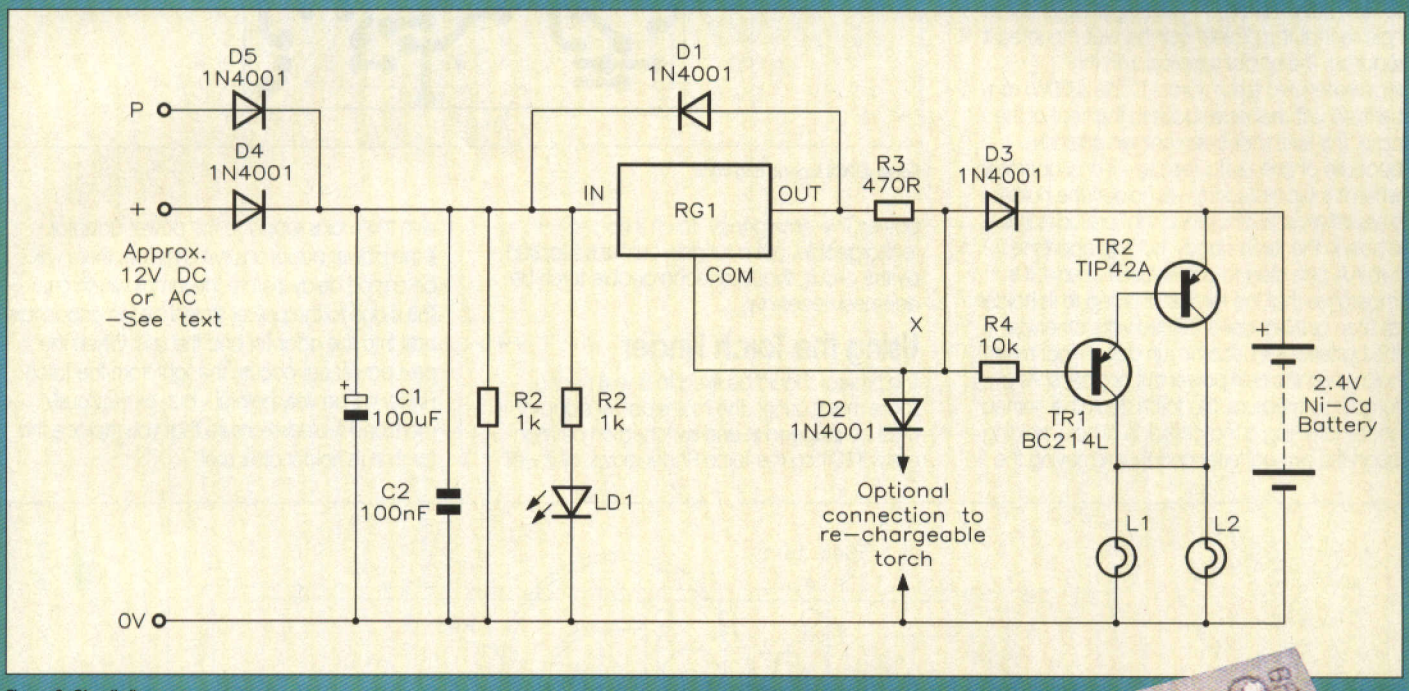


Figure 2. Circuit diagram.

Figure 2) in this circuit is positive when mains power is applied to the adaptor. During a power cut, however, the voltage at 'x' falls below 1V, and the Darlington pair is switched on, lighting the bulbs. Resistor R4 limits the current flowing from the base of TR1.

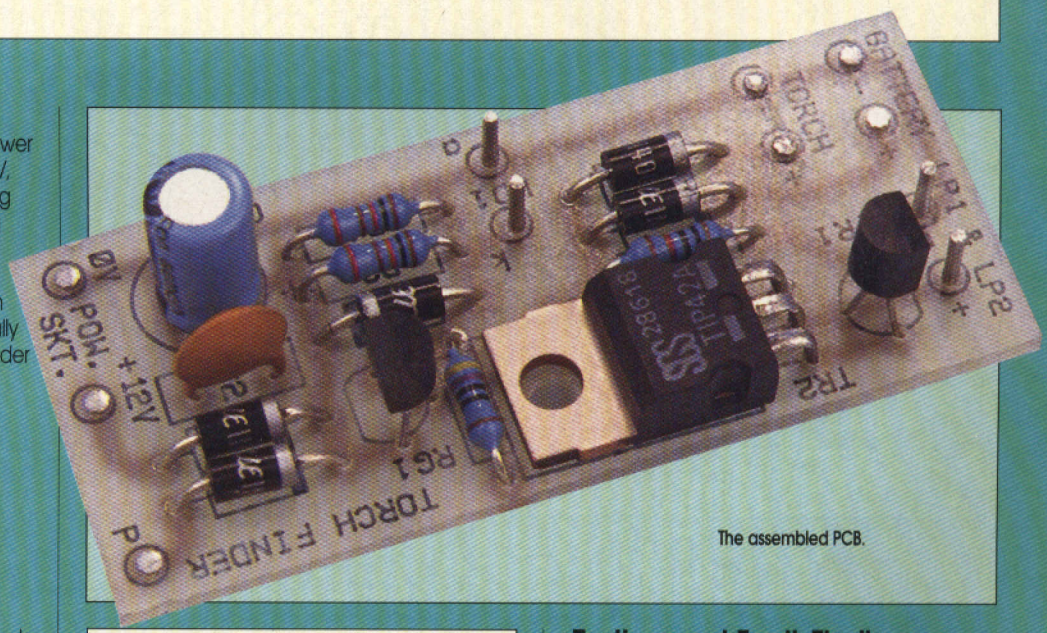
D4 is included as a reverse-polarity protection diode – after all, with some plug-in DC power units, it is all too easy to accidentally reverse the power connections! The Torch Finder may, as an alternative, be powered from a centre-tapped 9V-0V-9V transformer, for example YN15R; there is provision for an additional diode (D5) on the PCB design to allow for this.

PCB Construction

A suitable PCB layout is shown in Figure 4. Alternatively, you could make up this simple circuit on a spare piece of stripboard. Note that the PCB of Figure 4 is designed to fit exactly into the specified case – the case size may also be a constraint if you are taking the stripboard option. It is advisable to check that the PCB fits into the case before fitting any components, since it is very difficult to trim a PCB after construction.

Begin by fitting the smallest components, ensuring that the diodes are correctly aligned. Check the polarity of electrolytic capacitor C1, and ensure that TR1, TR2 and IC1 are fitted the correct way round.

The leads to external components should ideally be colour-coded to ensure that the LED, batteries and power socket are connected correctly. Note that the recommended twin 'AA' battery holder requires a PP3 battery clip to connect it.



The assembled PCB.

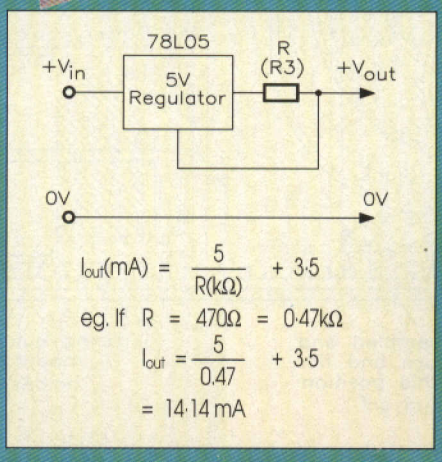


Figure 3. Using a 78L05 as a current regulator.

Testing and Fault-Finding

Testing may be accomplished more easily if a pair of charged Ni-Cd cells are available. Otherwise it may be necessary to leave the circuit connected to the power adaptor for some time before proper testing can take place. Alternatively, some dry cells could be employed for testing, but ensure that these are removed before connecting the circuit to any power supply since attempting to charge dry cells with this circuit could result in an explosion.

Assuming that power is not applied to the circuit, and that charged cells are placed in the battery holder, the bulbs should light up. If this is not the case, check the type and orientation of TR1, TR2 and D3. Check that the voltage across the Ni-Cd batteries is about 2·4V. The voltage at point 'x', relative to 0V, should be less than 1V.

Apply power to the input of the circuit. The lamps should go out and the LED should light up. If the LED fails to light immediately, disconnect the power adaptor and check its polarity (i.e. which way round it is connected). It is very easy to connect some power adaptors with the wrong polarity. If the LED still fails to light up, check its polarity, and check the voltage across it. This should be about 2V.

Final Assembly

A suitable housing for the project is PX2 (Order Code YU53H), and the PCB is designed to fit into the slots. Begin by drilling holes for the power socket, bulbs, and LED – not forgetting to drill a hole so that the project can be wall-mounted if required. The holder supplied with the recommended torch (Order Code JU20W) may be fixed with adhesive pads to the front of the case. This torch has been chosen primarily because of one useful feature – it only operates when it is separated from its holder (the holder is essentially a plastic prong that protudes into a hole in the torch's body, holding apart the two AA cells used to power it). Of course, it is imperative that the torch is returned to its holder as soon as it has been finished with, otherwise the batteries will become run down – not much help when the next power cut happens! As a temporary measure, the torch could be 'turned off' by jamming a matchstick in its hole, holding apart the two batteries and thus removing the power. This 'emergency' torch is not rechargeable, but a suitable output is supplied by the circuit, should a rechargeable torch be deemed necessary.

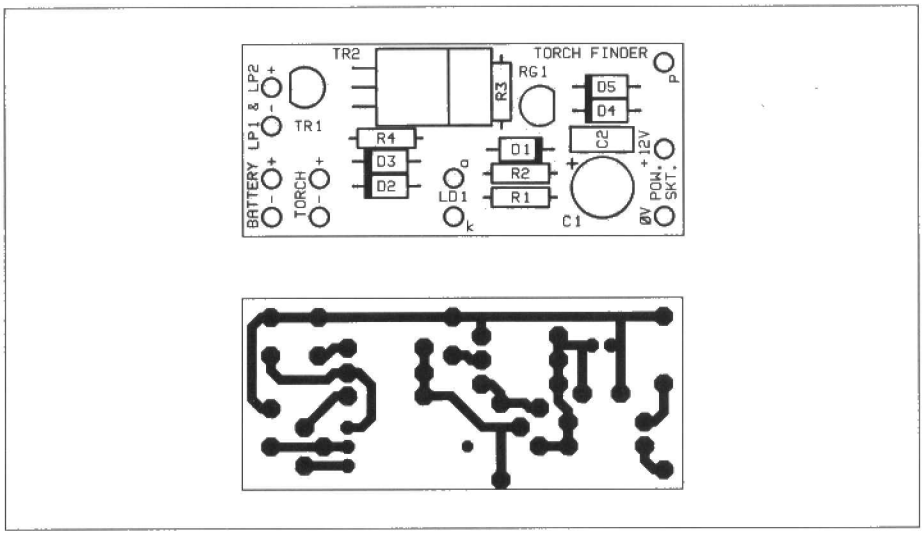


Figure 4. PCB legend and track.

Using the Torch Finder

The project should be fixed to a wall near a spare mains outlet. The mains power adaptor must be plugged in and switched on permanently. If LD1 on the Torch Finder glows, all is well with the mains supply to the power adaptor. If the power adaptor is switched off, there will be a short delay before the lamps switch on. This is due to the power stored by the capacitors built into the adaptor and the unit. When the next power cut occurs, the light from the Torch Finder will be very helpful – but, as previously mentioned, please ensure that you replace the torch in its holder after use!

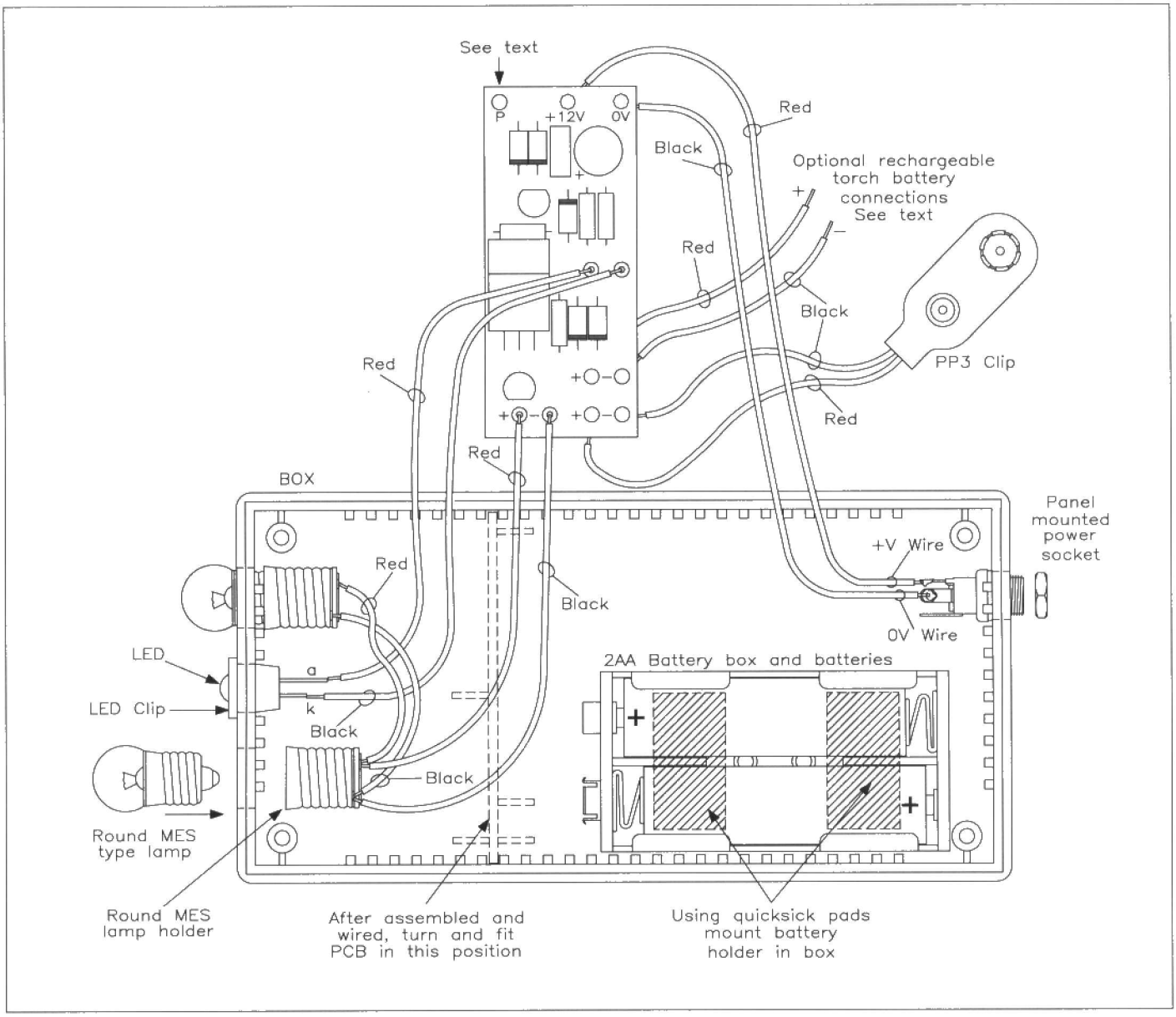


Figure 5. Wiring diagram.

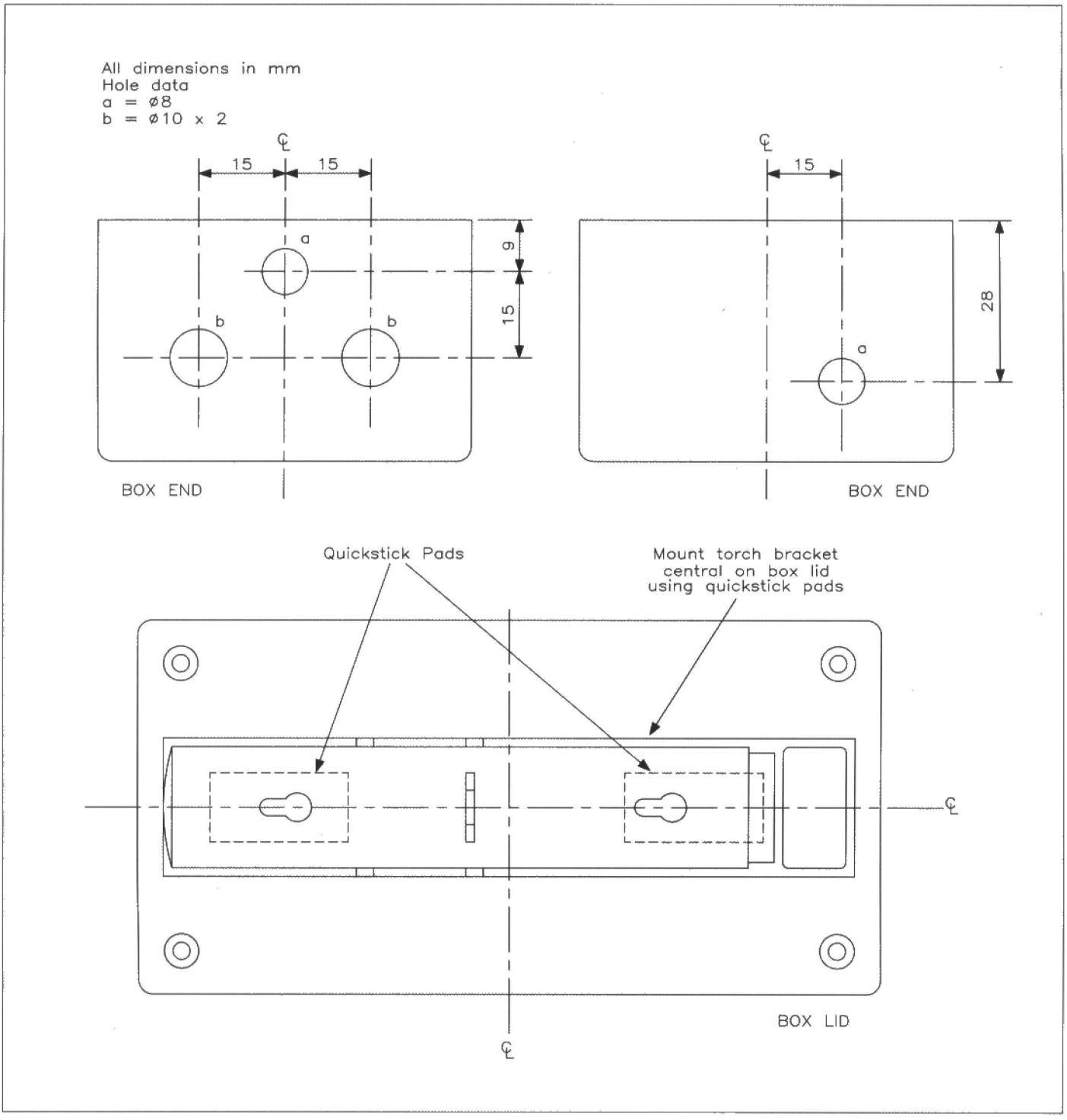


Figure 6. Box drilling.

TORCH FINDER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1,2	1k	2	(M1K)
R3	470Ω	1	(M470R)
R4	10k	1	(M10K)
CAPACITORS			
C1	100µF 25V PC Electrolytic	1	(FF11M)
C2	100nF Disc Ceramic	1	(BX03D)
SEMICONDUCTORS			
D1-5	1N4001	5	(QL73Q)
TR1	BC214L	1	(QB62S)
TR2	TIP42A	1	(QL18U)
RG1	µA78L05AWC	1	(QL26D)
LD1	LED 5mm Green	1	(WL28F)
MISCELLANEOUS			
	LED Clip 5mm	1	(UK15R
	2 'AA' Battery Box	1	(YR60Q)
PP3 Battery Clip		1	(HF28F)
Ni-Cd 'AA' Battery 600mAh		2	(JU55K)
Box PX2		1	(YU53H)
MES 2·5V Torch Bulb		2	(BT96E)
MES Bulb Holder		2	(JX87U)
PCB Pin 2145		1 Pkt	(FL24B)
Mains Power Adaptor (approx. 12V)		1	(e.g. YM85G)
Power Socket (suitable for adaptor)		1	(e.g. JK10L)
Emergency Torch		1	(JU20W)

The Maplin 'Get-You-Working' Service is not available for this project.

The above items are not available as a kit.

The History of Computers

4. The Fourth Attempt - Leibniz's Calculator: Improved Mechanisation

by Greg Grant

The Pascaline was neither a failure, nor a curiosity. Like ENIAC in our own time, it pointed the way – or rather, several ways. To start with, it actually calculated – and secondly, its major difficulty was known. Within eleven years of Pascal's death, a solution to its problem was found. The man who discovered it, and indeed made the Pascaline practical, was the Saxon Gottfried von Leibniz.

Undoubtedly one of the half-dozen truly staggering minds of the last three hundreds years, Leibniz was a logician, engineer, geologist, mathematician, philosopher, lawyer and historian. A prolific writer on a wide variety of subjects, many of his essays have yet to see the light of day, and it would be far easier to weigh his letters than count them! In fact, one historian of science and technology reckons that a bibliography of his writings would in itself amount to a small book!

Sometime between 1672 and 1674, during a stay in Paris, he heard of the Pascaline and its laborious method of counting. He immediately decided to look into both the device and its problem.

The first and most obvious snag was that if you wanted to multiply on a Pascaline, you had to re-enter a number repeatedly and add it to the running total.

Leibniz solved this in two ways. Firstly he designed a machine where, at the full 360° turn of a crank, a set number was automatically repeated. Secondly, he provided it with a multiplier cylinder having nine steps along its length. The latter gave decimal transfer as part of the normal machine operation. Figure 1 illustrates the construction of the multiplying cylinder or 'stepped reckoner', as its originator called it. So how did it work?

Figure 2 shows part of a later calculator that had all the technical characteristics of Leibniz's original. The machine's manipulative ability depended on the stepped cylinders (a). On top of each one, a cogwheel (b) moved forwards and backwards on shaft (c) via a Setting Switch (not shown for clarity) whose scale ran from 0 to 9, corresponding to the nine steps on the cylinder with which the cogwheel meshed.

Continued on page 47.

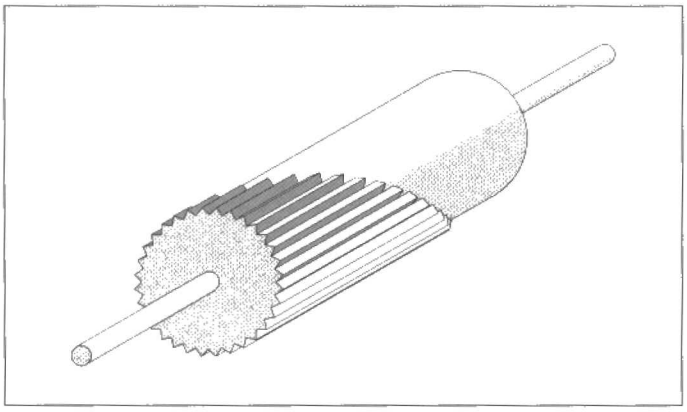
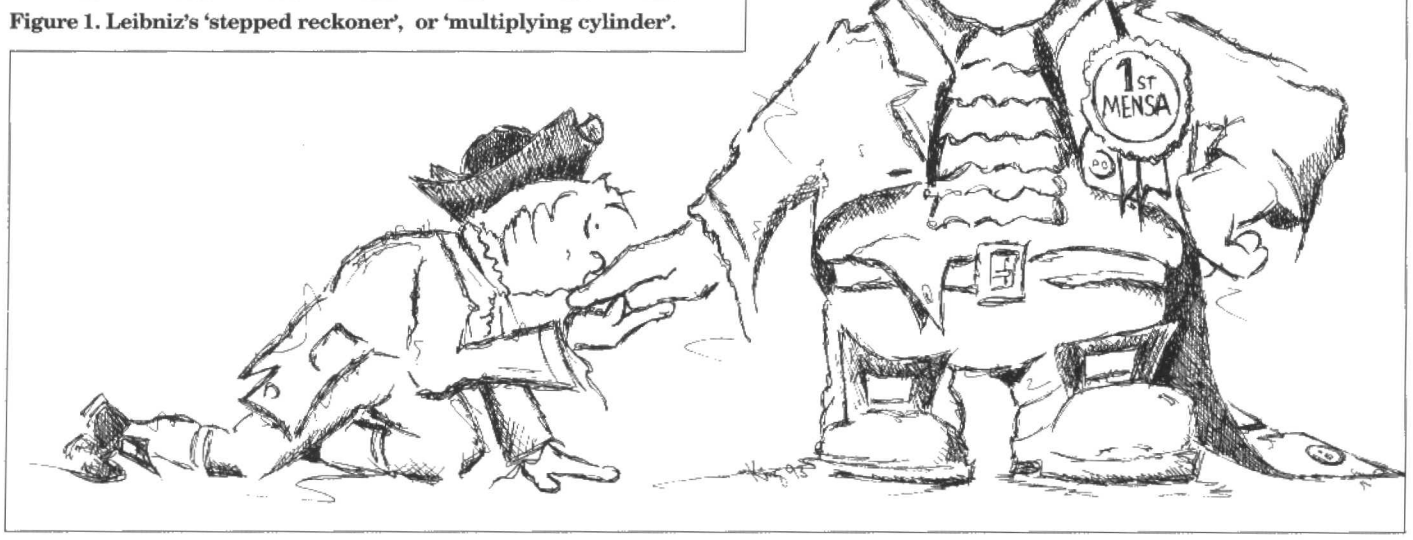


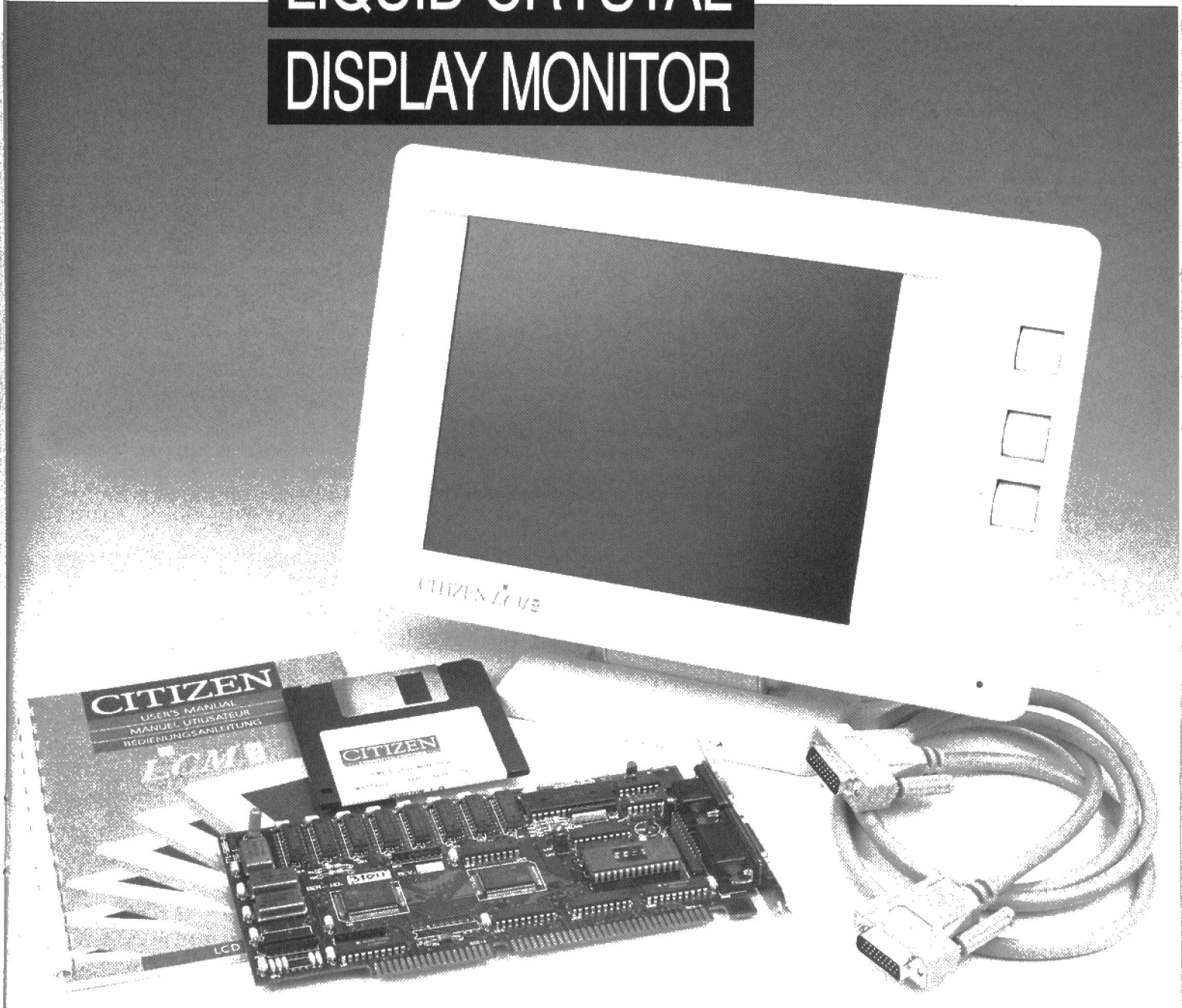
Figure 1. Leibniz's 'stepped reckoner', or 'multiplying cylinder'.



Reviewed by
John Mosely

CITIZEN LCM64 COMPACT LIQUID CRYSTAL DISPLAY MONITOR

This is Citizen's first venture into the monochrome LCD monitor field. Citizen believe they have identified a market for this type of monitor, with possible applications being computer terminals, customer reservation systems, touch screen information systems and point of sales systems. Typical users may well include travel agents, airlines, hotels, financial institutions and Government bodies.



Specification

Model:	Citizen LCM64
Compatibility:	Suitable for use with IBM PC/XT/AT compatible computers (286, 386, 486)
Display type:	640 x 480 RCF, STN, monochrome transmissive
Back light:	Cold cathode fluorescent tube
Pixel size:	0·27 x 0·27mm
Effective dot pitch:	0·30mm
Display aspect ratio:	1:1·33
Display contrast ratio:	10:1
Frame frequency:	70Hz
Viewing area:	197 x 149mm (10in. diagonal)
Display controller card:	26-pin, 16-bit ISA bus (switchable to 8 bit)
Graphics modes:	All modes up to and including VGA
Dimensions of monitor head:	313 x 33 x 205mm
Weight:	1.6kg

The Benefits

The British-built(!) unit is certainly very compact, requiring 60% less space than a conventional CRT monitor. There are no known harmful effects since there is negligible radiation emission – less than a household light bulb, Citizen claim; while a flicker-free display and non-glare flat screen reduce eye strain and fatigue. This should make the monitor user friendly if nothing else. Because of its compact size, it can be desk or wall mounted to provide an ideal viewing position, and since it is powered direct from the PC, there is no mains lead or socket to worry about. There is only one cable, and that connects to a dedicated 8/16-bit ISA-bus PC-compatible interface card that is supplied with the monitor.

The cold cathode fluorescent tube (back light) provides a cool operating temperature which increases life expectancy and gives an evenly illuminated display. Additionally, since there is no EHT involved (over 16kV in most colour CRT-based monitors), there are no ozone emissions. Another benefit is that the monitor screen keeps cleaner, unlike a CRT, which attracts dirt due to electrostatic charge build up on the face of the tube.

The Monitor

The LCM64 uses Citizen's own high performance, back lit 640 x 480 VGA super twist nematic liquid crystal display, which incorporates a retardation control film (RCF). Super twist nematic (STN) technology uses crystal molecules that turn light through 270°, while RCF – a thin polymer layer – gives the LCD its black and white appearance.

Installation

Installation is reasonably straightforward. The existing video driver card in the PC is removed, and the supplied card inserted into the vacant slot. The video card is then connected to the LCD monitor by means of a multiway D-type connector. An additional output is provided to allow connection of your original monitor. A disk containing several 'monitor' utilities is provided, one of which allows the user to switch between the two monitors.

Replacing the PC's case and switching on, produces an output on the LCD monitor. However, after my PC finished its initial start up routine, the LCD monitor produced a reasonable reproduction of Egyptian hieroglyphics! A quick look through the supplied manual resulted in no solution to the problem. However, it was reasonable to assume that the problem must be a set up mismatch. A quick telephone call to Citizen produced a solution, and judging by the friendly engineer's rapid diagnosis, it was probably a problem that he was familiar with – perhaps future manuals will have a section on possible problems. In this instance, it was a case of switching off the video shadow RAM, which means accessing the PC's BIOS set up utility. This was very quickly done, and all was well.

The supplied utilities include various options, and it is recommended that the utilities are copied to the hard disk's root directory, or better still, copied into a 'monitor utilities' directory (with the path to the directory added to the existing PATH definition in the AUTOEXEC.BAT file). The LCD monitor can be made to emulate VGA (default setting), EGA, MGA and CGA so that it can be used in the same mode as your existing monitor.

Other useful utilities include:

Expanded mode – This allows a 640 x 400 output to fill the 640 x 480 LCD display.

Auto-centring – The top of unexpanded modes are aligned with the top edge of the display or centres unexpanded modes between the top and bottom of the display (default mode).

Enable normal or reverse video – This is a keyboard controlled equivalent of the front panel control (black characters on a white background or white characters on a black background).

Width Compression Options – There are several width compression options that can be invoked to suit your requirements. For instance, when it is necessary to drive the display, which is 640 pixels wide, with either a 720 display mode (HGC graphics mode) or a 360 pixel wide display in double display mode (VGA graphics mode 70 with a resolution of 360 x 480 and 256 colours).

Switcher Utility – This is a 'terminate and stay resident' (TSR) program that allows utilities to be 'toggled' whenever certain keystroke commands are entered.

In Use

To the right of the LCD monitor are the rotary controls. The top one is a three position switch: OFF; ON (normal) with black characters on white background; ON (inverse) with white characters on black background. The other two controls are

the normal brightness and contrast. Citizen suggest that the brightness is initially set to minimum and then the contrast should be adjusted for a well-defined image, and then the brightness adjusted as required.

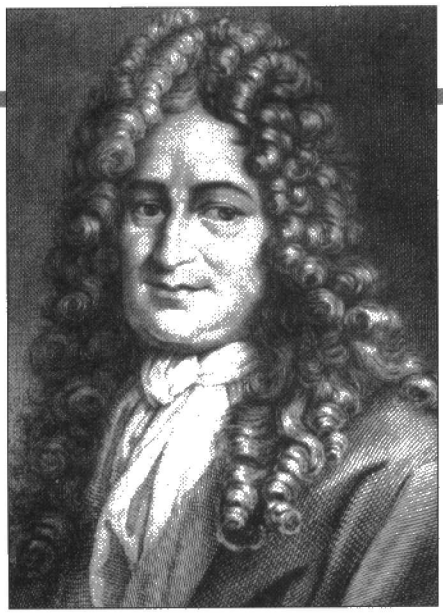
Once set up and adjusted, the monitor performed extremely well producing a bright, clear image, and has continued to do so over the 4 months that it has been on test. All the utilities worked and it was very easy to toggle between the LCD monitor and my normal monitor, by simply pressing the <CONTROL>, <SHIFT> and 'D' keys together. I believe that LCD monitors (in general) are only completely satisfactory for displaying text or graphics without too much continuous screen activity, as any rapid movement becomes a blur – a quick push on the mouse and the cursor disappears! But given Citizen's intended market, then this LCD monitor would be very well suited, as it works well in bright ambient conditions, and can be used for long periods without fatigue. I would strongly advise that the monitor is permanently fixed to a surface, as it is very light and can easily be knocked over. The cable connector does not appear to be very robust, and may also cause problems if the connecting cable is not suitably secured. If care is taken in installing the LCD monitor, then certainly it should perform for many years, and unlike a CRT monitor, the display should not deteriorate with prolonged use.

However, there is one snag – the price. At a recommended price (at the time of writing) of £699 (plus VAT) it could be difficult to justify its purchase, although, as I have said, it should have a long and trouble free life. But at that price you can easily buy another 386 PC which might be more useful in an office or reception area.

Thanks are due to Citizen for providing the monitor for an extended period.

Citizen may be contacted at:

Citizen Europe Ltd., Citizen House, 11 Waterside Drive, Langley Business Park, Langley, Berkshire, SL3 6EZ. Tel: (0753) 584111, Fax: (0753) 582442.



The History of Computers continued from page 44.

The number you wanted to multiply was set by the 'setting switch', and when crank handle (d) was turned clockwise once, the number set could be seen in the window of the product register because the dials (e) were connected to the crank axle via bevel gears.

Each time the crank handle was turned the multiplicand was added to the number which could be read on the product register and, after seven revolutions – Leibniz's original model had eight stepped cylinders – the result of the set number multiplied seven times could be read off the quotient indicator (f).

For division, the stepped cylinders reversed their direction of rotation.

This was not all. Leibniz later designed a machine capable of the resolution of square and cube roots. It was never built, however, because it was at this juncture that Leibniz – like Pascal before him – came up against the major difficulty of the time; the engineering 'standards' of the day. They simply weren't up to the task.

No matter. Leibniz's contributions were enormous and had earned him an immense reputation throughout Europe. In fact, he spent the remainder of his life as an advisor to a variety of boorish monarchs.

Leibniz's legacy to future generations of scientists and engineers would be twofold. Apart from the ideas that would form the basis of all future mechanical calculators (and also, for that matter, domestic gas meters), there were, of course, his mathematical gifts.

Quite apart from being the co-discoverer of Differential Calculus, he was also the earliest Western mathematician to not only look into binary notation, but write about it. He even thought about building a binary calculator which – hardly surprisingly – didn't progress beyond the imagination stage.

Virtually all mechanical calculators, built over the next century and a half, were greater or lesser imitations of Leibniz's machine. One such device was that designed and built by the third Earl of Stanhope; it had eight Leibniz drums and a sliding carriage. It was good, being not only accurate but also relatively simple enough for volume production.

However, it would be the early years of the 19th century, before minds of Leibniz's standard would attempt to take his work further. We'll meet the first of them in the next part.

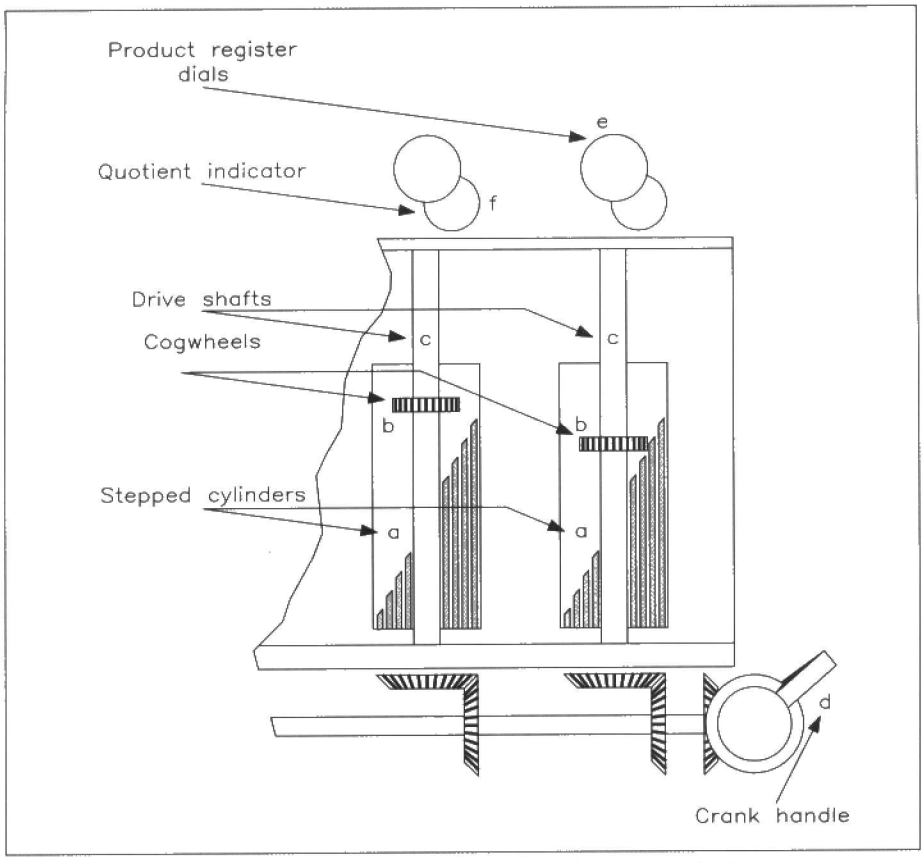


Figure 2. Leibniz's 'stepped cylinder', in action in a mechanical calculator.

Industrial Electronics Assembly-

PART 2

Placement head, about to place a surface-mounted integrated circuit component onto a PCB (Dynapert).

A World Apart?

by Keith Brindley

Placement of Surface Mount Components

Last month, we ended by looking at how the adhesive or solder paste is applied to the PCB. To recap, this procedure is specific to surface mount assembly – because they have no leads to hold them to the PCB, some other method of attachment must be used. After application of the relevant adhesive medium, components are placed (or onserted) on the PCB. While the principles of this remain the same as the principles of inserting leaded components onto through-hole PCBs (loading each component, positioning PCB under component head and so on), the process is dramatically simpler for surface-mounted components. This is because surface-mounted components have no leads to be preformed, clinched, cropped or get in the way of the placement head.

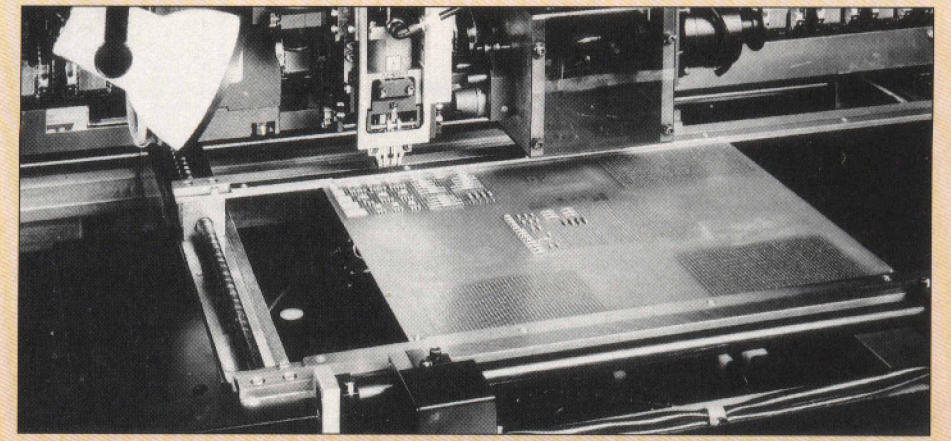
One of the beauties of having a new type of component to use (surface-mounted components have really only been 'widely' available for the last few years) is that manufacturers can specify them to be of the right size and shape for automated assembly. Surface-mounted components, therefore, are designed to be easily handled by machines. They are supplied in three main ways:

(i) bulk form (tipped into a hopper located at the placement head)

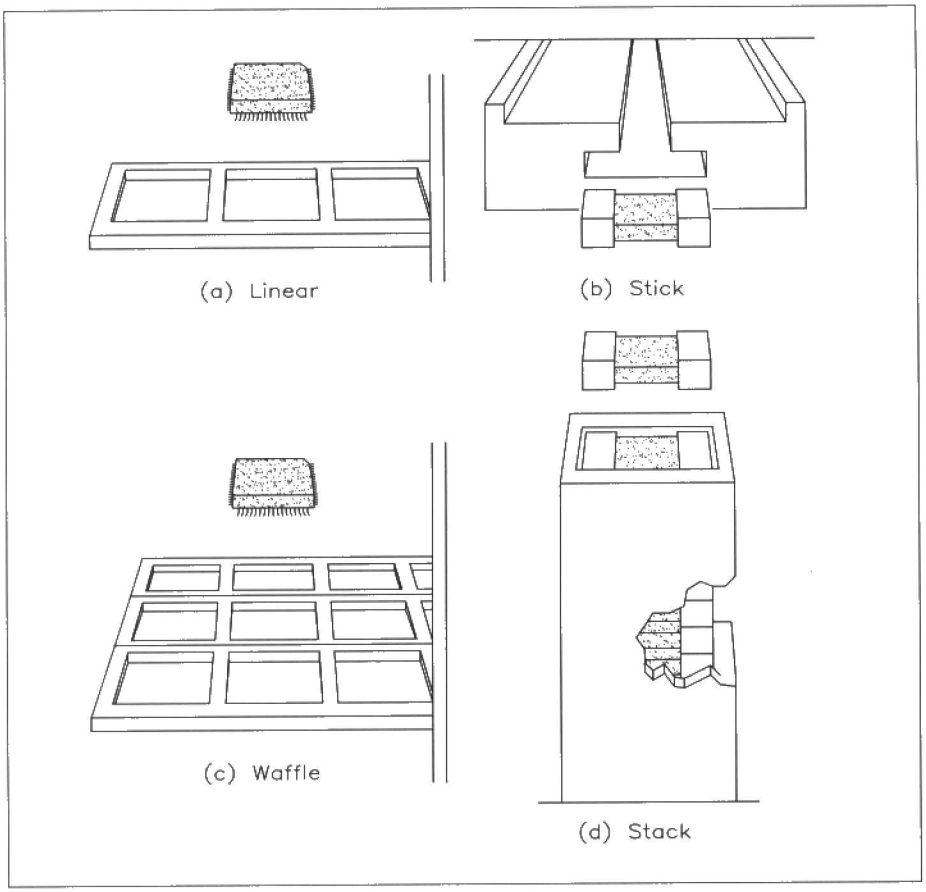
(ii) magazines (of 200 or more components – refer to Figure 1)

(iii) taped (in standardised sizes and types – see Figure 2)

Placement heads often allow fairly accurate movement in both horizontal axes (X and Y), although sometimes the PCB itself is moved underneath a station-

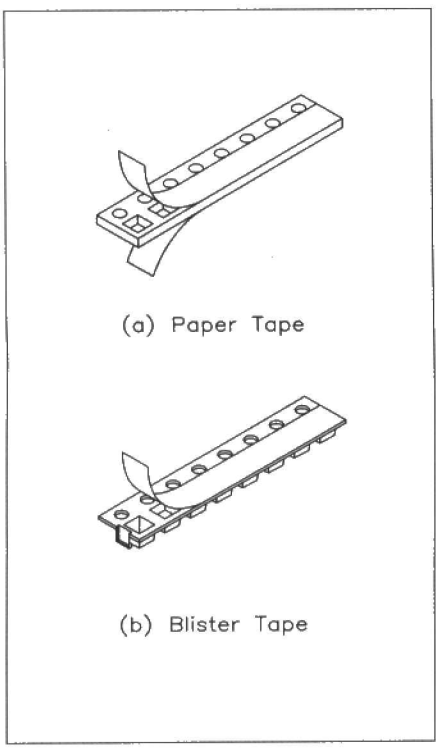


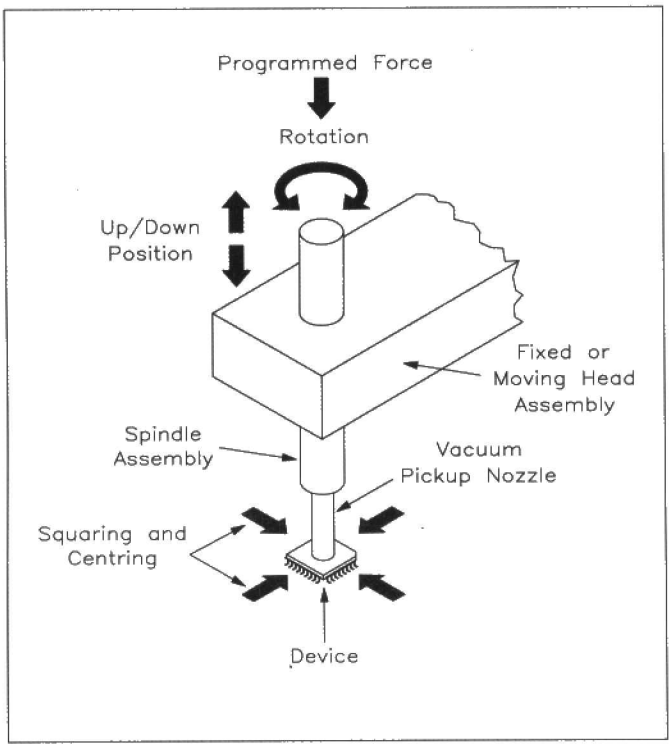
Axial-leaded component insertion head (Panasert).



an absolute position. This can be done using mechanical arms which 'move in' on the component, as shown in Figure 3. Alternatively, the head can move the component to a fixed jig, comprising (in its simplest form) two straight edges at 90°. Centring by a jig method is usually referred to as *taking the component to a placement centre*. Centring using either of these methods usually allows repeatability of the component on the placement head to within 0·025mm. This doesn't mean, however, that the component is positioned to such accuracy on the board. Factors such as the machine's mechanical tolerances, PCB size tolerances, as well as the 'sliding effect' that solder paste or adhesive can have on the component as it is placed, may not allow placement to the accuracy required. Although this type of machine can usually place components of just a few terminals sufficiently accurately, it is not really capable of accurately placing multiterminal integrated circuit components.

Higher accuracies of placement are achieved with machines that use optical recognition to aid centring of components, as they are ultimately positioned on the circuit board. These systems, known as





Above Left:
Figure 1. Main forms of surface-mounted component magazines.

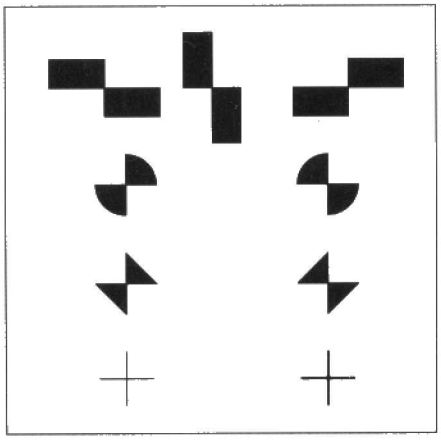
Far Left:
Figure 2. Surface-mounted component tapes.

Left:
Figure 3. Surface-mounted component placement head.

Below:
Figure 4. Fiducials commonly used to aid vision-assisted placement of surface-mounted components.

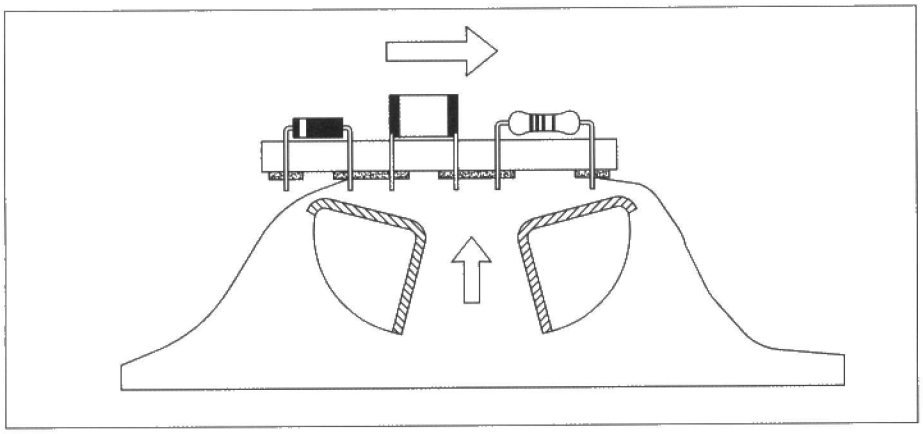
ary (horizontally at least!) head. Typically, the head holds a vacuum pick up nozzle mounted on a spindle assembly, which can be moved up and down, as well as being rotatable – see Figure 3. Some heads allow rotational increments of as low as 0·01° – important where multiterminal integrated circuit components are to be placed. The force with which the head's spindle is moved up and down is usually programmable, so that various consistencies of solder paste or adhesive may be catered for as the machine places the component.

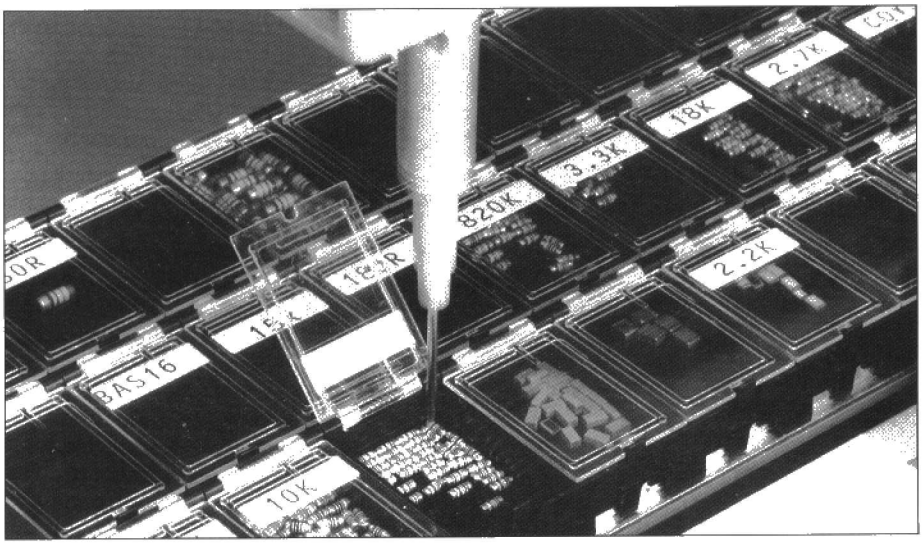
After being picked up by the head, the component must be centred so that it is in

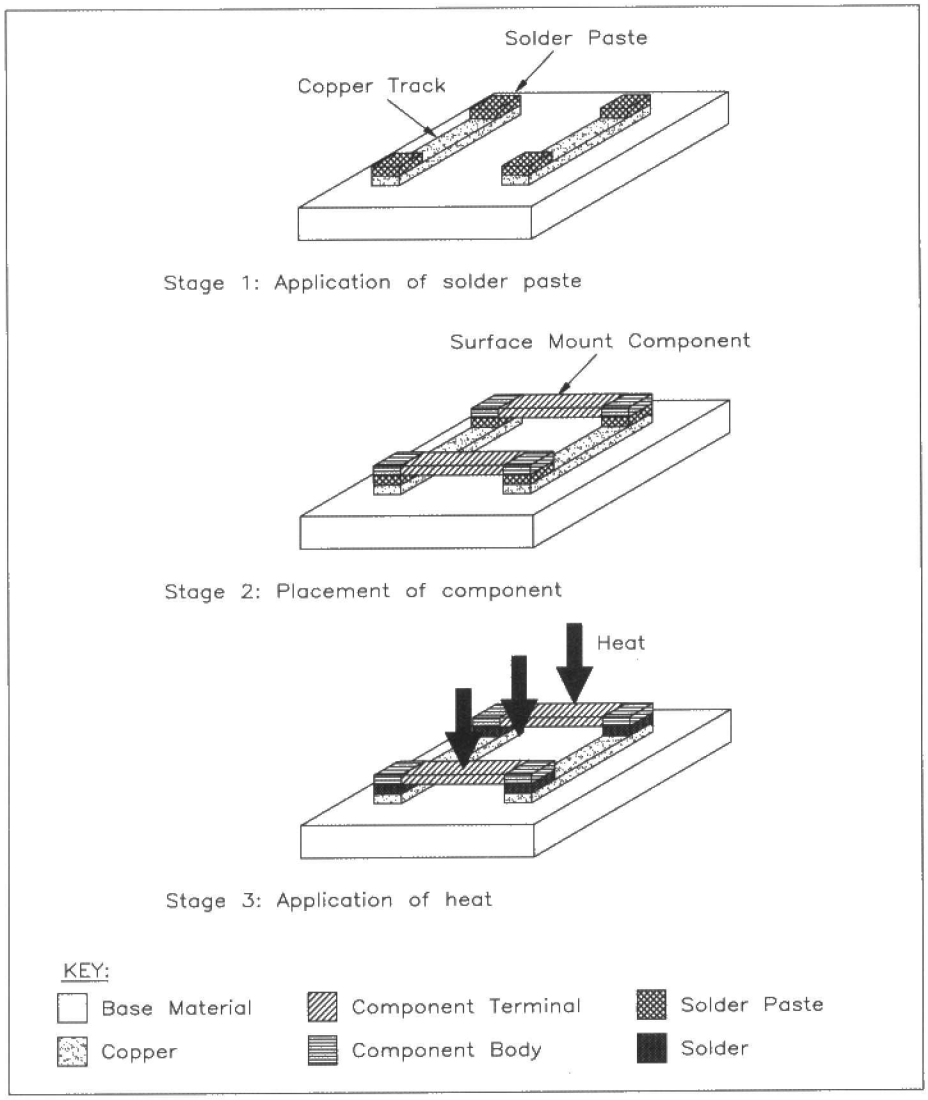


vision systems, incorporate a camera mounted on the placement head. This camera monitors the position of the head in relation to the circuit board. Optically recognizable location marks on the circuit board (known as *fiducials*) are detected, using the camera, by the machine's computer-controller, so that extremely fine adjustments may be made, prior to final placement. Typical fiducials are shown in Figure 4.

Accuracies of vision placement systems may be as small as ±0·02mm, with rotational inaccuracies within 0·2°. Most machines using vision are capable of high-accuracy placement to ±0·1 mm.







Top: Figure 5. Wave soldering principle, the usual CS (i.e., component/solder) soldering process.
Centre: Picking up components from component trays, using suction tipped nozzle, during hand-assembly of surface-mounted printed circuit boards (Groatmoor).
Bottom: Figure 6. Principle of SC (i.e., solder/component) soldering processes.

After component placement, the adhesive or solder paste must be dried (cured in the case of adhesive) and the assembly soldered. Unlike through-hole PCBs, however (where solder is usually applied to the opposite side of the board to the components), surface-mounted assemblies must be soldered on the same side as the components, since that is where their terminations are.

Machine Soldering Processes

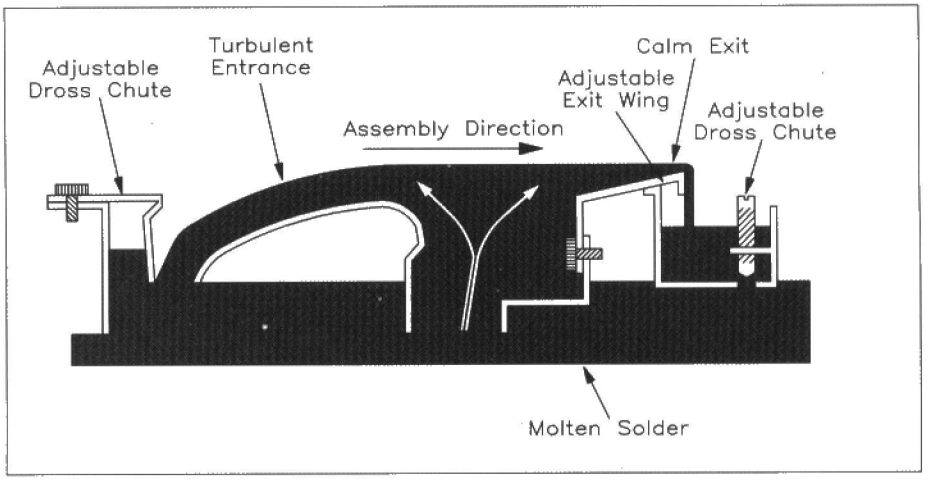
While there remain a small number of hand soldering processes in industrial electronics assembly, most processes are now undertaken by soldering machines. Hand soldering is a tricky process which depends totally on the experience and skill of the operator for its reliability. Machine soldering, on the other hand, is of fixed and assured reliability. As long as large numbers of assemblies are to be soldered, hand soldering is slow and thus expensive, while machine soldering is rapid and thus relatively cheap. As far as this is concerned, one of the aims of machine soldering is to provide a conveyor belt process in which loose components and bare PCBs are entered at one end of the belt, and fully assembled, soldered, cleaned and tested assemblies are taken off at the other end.

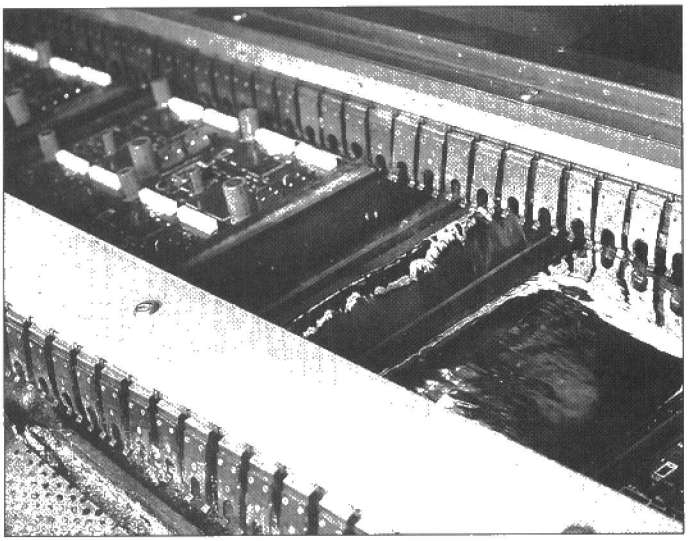
There are two main categories of machine soldering processes:

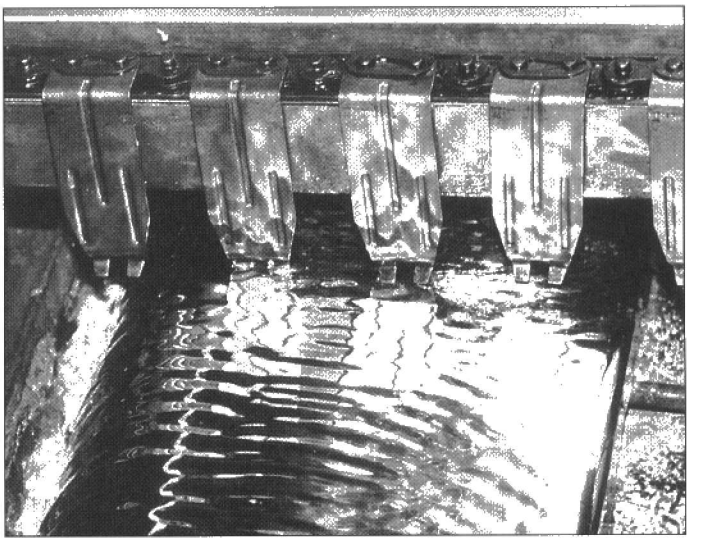
(i) those processes which rely on insertion or onsertion of components *prior* to the application of *solder – component/solder* (CS) processes (sometimes referred to, somewhat more graphically, as *flow soldering processes*). CS processes are typified in what is known as *wave soldering*. Wave soldering processes use a pump to create a 'wave' of solder over which the assembled and fluxed board is passed, as shown in Figure 5. Note that there *are* other types of CS process, but *wave soldering* is by far the most common.

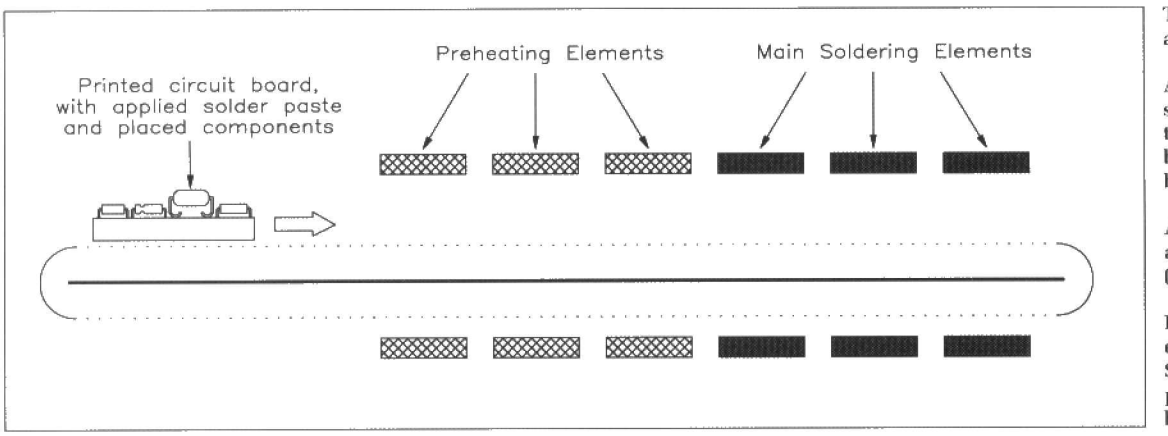
(ii) those processes which rely on onsertion of components *after* application of *solder – solder/component* (SC) processes. These are often referred to as *reflow* soldering processes, since the original idea uses a layer of previously applied solid solder, which is reheated to cause it to melt (that is, 'flow' again i.e. 'reflow'). Current SC processes are used primarily in surface-mounting assembly production, where solder and flux are applied as a paste followed by the placement of components and the application of heat (Figure 6). Under this light, the term *reflow* is obviously something of a misnomer, as solder and flux paste can in no way be thought of as solid solder.

The category of soldering machine used depends primarily on the components to be used in an assembly. CS soldering is best when components are leaded (or the assembly contains a mixture of leaded and leadless). This is simply because it is difficult to solder a leaded component by SC means. On the other hand, it is perfectly possible to solder leadless components by either SC or CS means. The limiting factor to this is usually how small a leadless component is – in other words, the number of terminations that have to be sol-









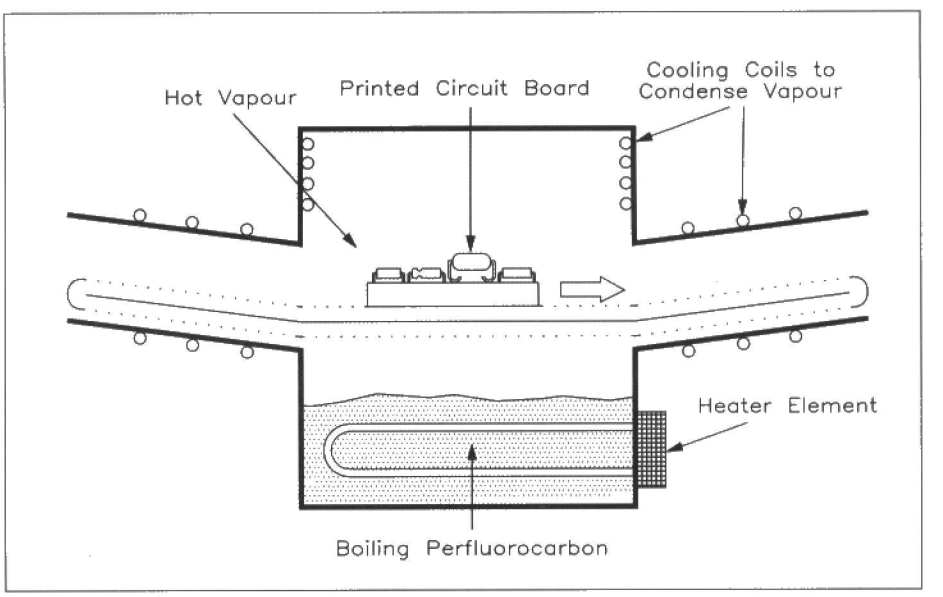
Top: Figure 7. A supported asymmetrical wave.

Above left: Double-wave soldering machine. First turbulent wave, followed by second calm wave, can be seen (Siemens).

Above right: Supported asymmetrical solder wave (Electrovert).

Left: Figure 8. Heating elements in an infra-red SC soldering machine are positioned above and below assemblies.

Right: Figure 9. Principle of a vapour phase SC soldering machine.



dered within a given area. With leadless components of, say, 300 terminations, spaced just a fraction of a millimetre apart, it is sometimes difficult to ensure that a solder wave accurately solders each individual termination without bridging or skipping some. So, where multiterminal leadless components are to be soldered, an SC soldering process is normal.

CS Soldering

In practice, there are many different types of waves in CS soldering machines, and many are used successfully to some extent. However, the majority of wave soldering machines in industry use a variation of a particular shape which has

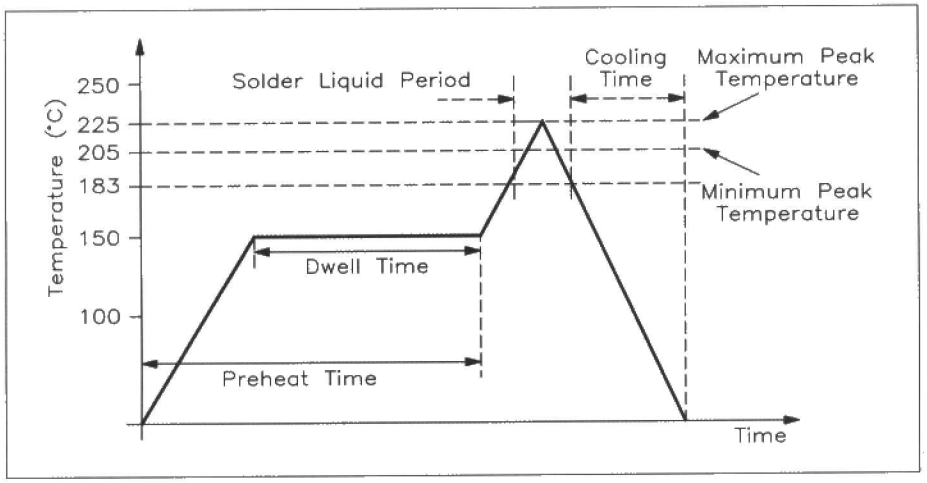


Figure 10. Typical soldering machine temperature profile, showing four main stages.

become more or less the default, simply because it gives good results when soldering *most* types of components. This general-purpose wave is technically known as a supported asymmetrical wave, and is shown in cross-section in Figure 7. Fast solder flow at the entrance to the wave ensures there is significant solder turbulence, thus helping to force molten solder into the smallest nooks and crannies of an assembly. A calm exit from the wave, caused by a slow solder flow over the exit wing, ensures that any excess solder, which might otherwise cause bridging between component terminals and tracks, is removed. Other machines may use two waves to create the same effects, the first wave being turbulent, while the second is calm.

SC Soldering Processes

There are two main types of SC soldering processes, although there are many subsidiary methods. In the first, infra-red heat is applied to an assembly to the extent that the solid solder paste around each component's terminals melts to form solder. Figure 8 shows the principle of an infra-red SC soldering machine.

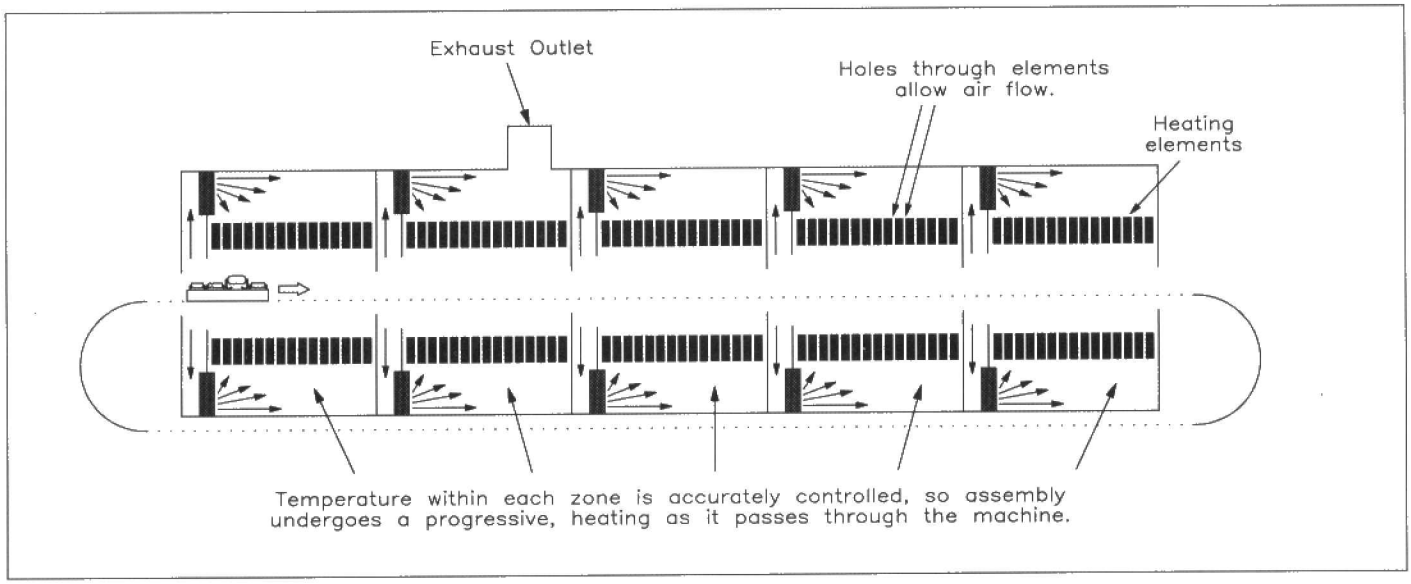
The second form of SC soldering process is the *vapour phase* process, in which an assembly is soldered in the hot vapour above a boiling liquid (refer to Figure 9). The liquid (usually a perfluorocarbon) is chosen to have a boiling point at just a few degrees of temperature above the melting-point of solder. As a result, the solder temperature can never rise above the liquid's boiling point. This can be an advantage.

Temperature Profiles

This brings us to the control of temperature within soldering machines. As we have just seen, a hot vapour soldering process guarantees the maximum temperature an assembly can reach. This means that some components, which can be damaged by heat, can be catered for. But the rate at which the assembly is taken to that temperature is also critical.

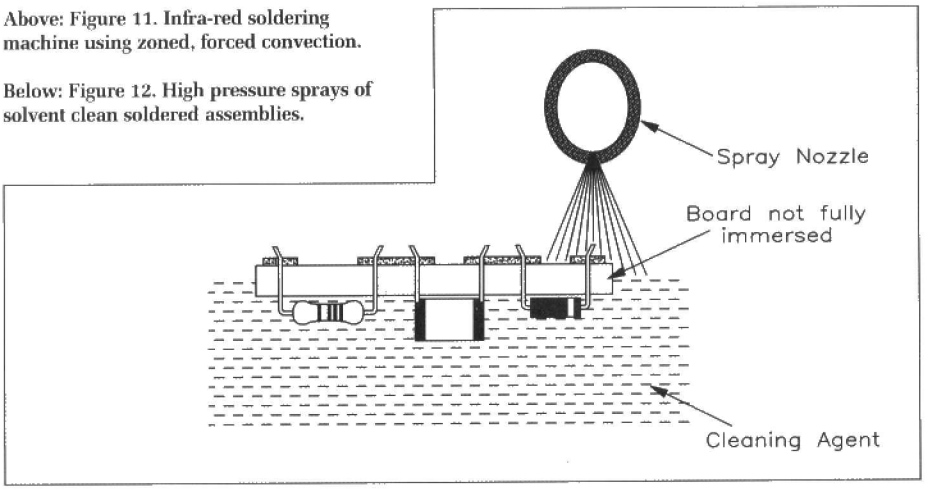
As a result, soldering machines of all types are usually specified in terms of their soldering profiles – simply a graph of temperature within the machine, and the time taken for the assembly to pass through it. A typical profile is shown in Figure 10. The profile required by an assembly depends on the components used in that assembly. Large components need a long preheat time to allow the component mass to warm up sufficiently. Small components can be heated up much more quickly.

Any modern soldering machine should have a means to carefully control its temperature profile. This usually entails heating elements (most often infra-red)


Exhaust Outlet
Holes through elements allow air flow.
Heating elements
Temperature within each zone is accurately controlled, so assembly undergoes a progressive, heating as it passes through the machine.

Above: Figure 11. Infra-red soldering machine using zoned, forced convection.

Below: Figure 12. High pressure sprays of solvent clean soldered assemblies.



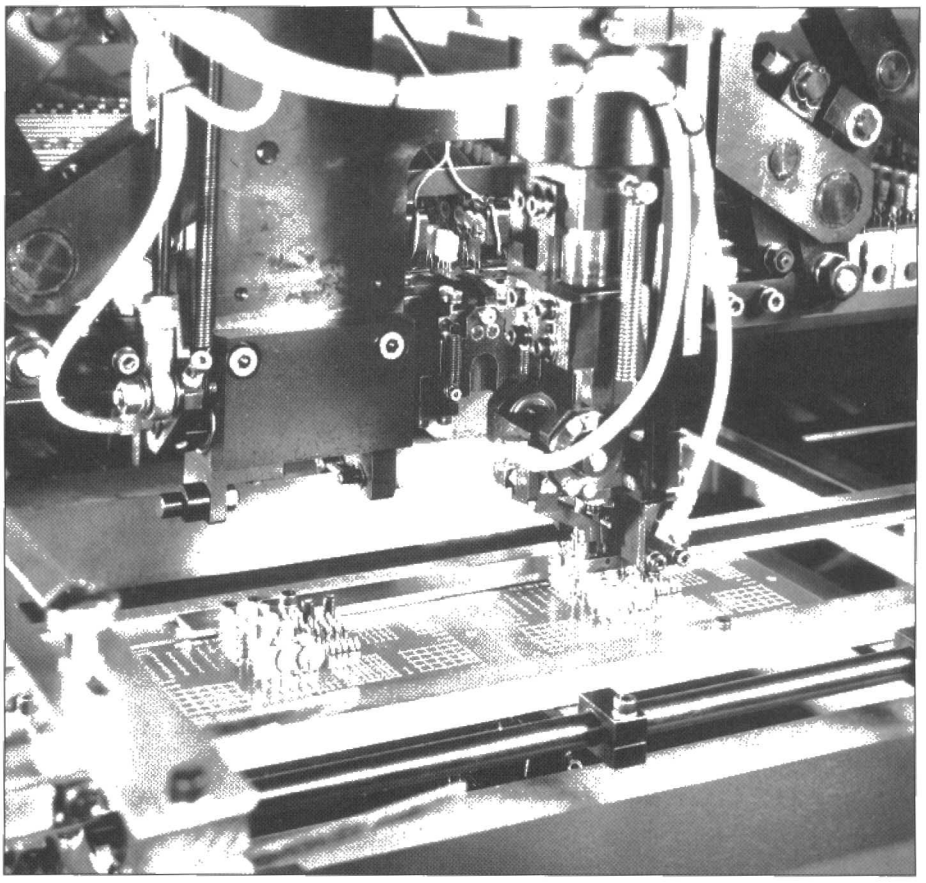
positioned before the actual soldering point within a machine. For obvious reasons, these are known as preheating elements. By controlling the temperature of these *preheat* elements, the temperature experienced by an assembly can be controlled in a rapid (but not *too* rapid) rise. Basically, the more elements present, the more control you have at any point.

In infra-red soldering machines, this can be taken a stage further by splitting the machines into individual zones, each with its own set of heating elements, and forced movement of air (known as *forced convection*). This gives an extremely accurate and controlled system, with well-defined profiles. A modern infra-red soldering system of this type is shown in Figure 11.

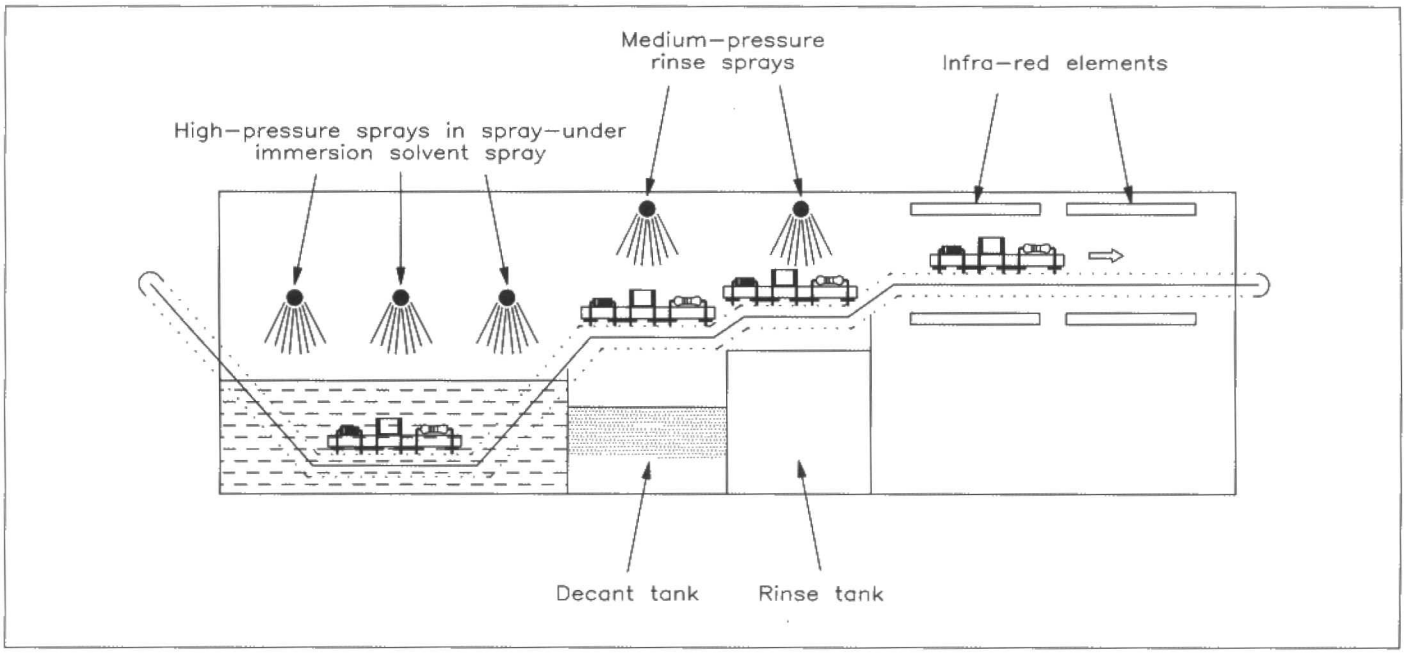
Cleaning

It is often necessary to clean assemblies after soldering. Residues of the fluxes used in the soldering process are quite corrosive, so depending on which flux is used and the final requirements of the assembly, cleaning may be called for. Not so long ago the preferred method of cleaning was to wash the assembly in a chlorofluorocarbon (CFC) solvent. This has the advantage of being able to remove just about any form of residue left after soldering so – in this respect alone – forms the ideal cleaning process. But the environmental disadvantages of CFCs are now well-known, and manufacturers are turning to systems with no environmentally damaging attributes.

Other solvents are now common, and still others are being developed. Often these solvents are organically-based, although some are based on the use of water together with a chemical agent.



Right: Radial-leaded component insertion head (Panasert).



Below: Figure 13. Complete semi-aqueous cleaning machine.

Generally, high-pressure sprays of solvent are used, which strike the assembly with a force sufficient to dislodge residues (Figure 12). In a semi-aqueous cleaning machine (Figure 13), decant and rinse tanks are used to successively extract residues, allowing the cleaning agent to be recycled back to the first stage. Finally, the assemblies are dried as they leave the cleaning machine.

Lessons for the Reader

While not every reader of 'Electronics' will be involved with any of the industrial electronics assembly processes in this article, there is just one thing which *all* readers should appreciate.

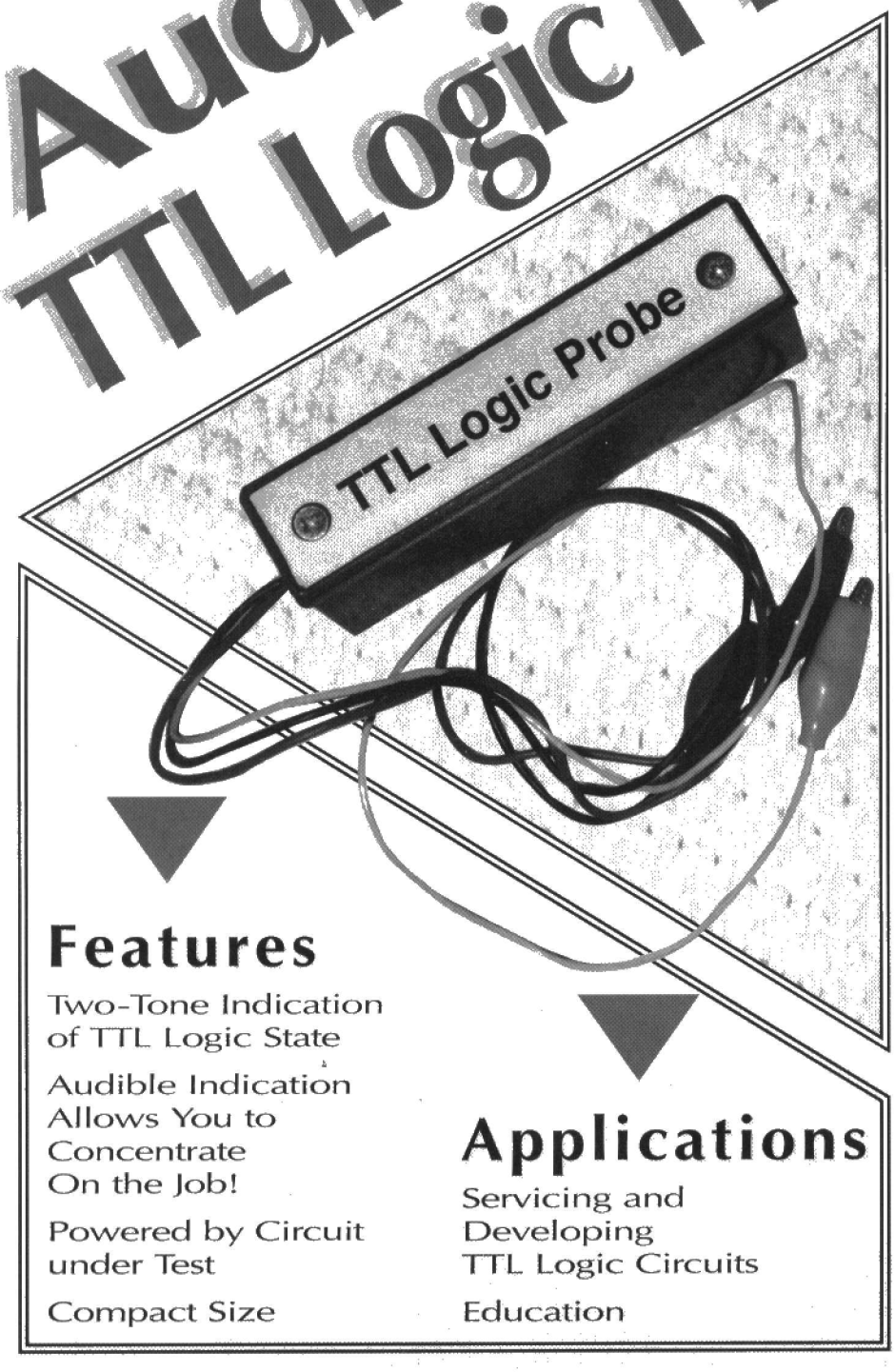
The components used to build projects in electronics magazines are limited in use, as far as electronics manufacture goes. Within a few short years it may be impossible to buy the components – resistors, capacitors, integrated circuits and so on – that are commonplace today. Surface-mounted components already exist where no such conventional components exist. As more and more manufacturers incorporate more and more leadless components, there becomes less and less need to have leaded components at all. Eventually (somewhere within the next ten years) manufacturers will probably all use nothing but surface-mounted components. As a result there may be no conventional components left at all. Take it or leave it – constructional projects in ten to twenty years time will use surface-mounted components! If you don't believe it, think of valves (remember them?). Thirty years ago they were used in most constructional projects. In more recent times (at least up until the renaissance of the valve for audio applications), only a brave (maybe foolhardy) magazine features a valve-based project.

How this change from conventional leaded to surface-mounted leadless components will affect the practices you will need to follow, on the other hand, is at yet uncertain. What is certain, however, is that construction (and servicing) of circuits using surface-mounted components will be a lot more difficult (steady hand, the right – and expensive – set of tools), at least as far as the home constructor is concerned.

Keith Brindley is a freelance writer and publisher who has written several electronics and computing books – many of them available from Maplin. His book 'Electronics Assembly Handbook', which deals specifically with the topics in this article to a much greater depth, is available from Maplin by ordering WT15R.

Audible TTL Logic Probe

by Terry Pinnell



Features

Two-Tone Indication of TTL Logic State

Audible Indication Allows You to Concentrate On the Job!

Powered by Circuit under Test

Compact Size

Applications

Servicing and Developing TTL Logic Circuits

Education

Listening to Logic

I still have a large number of TTL ICs from my hoarding phase, so despite my preference nowadays for CMOS I try to use them in projects whenever possible. For testing or repairing a TTL circuit, I have found that an audible indication of logic level is often much more useful than a visible one. The simple unit described here produces high and low tones for high and low input levels respectively (logically enough, you could say!).

Conventional logic testers that use an LED to indicate high or low voltage are generally fine, and they often have the useful additional facility of detecting very short pulses. Sometimes, however, they can be awkward to use. For example, it can be tricky to keep a probe steady on a pin while looking at an LED, and there is a risk of the probes slipping and shorting adjacent pins or, in the case of crowded boards, shorting to a nearby component lead.

Another advantage of this audible logic tester is that you can monitor the test point using its miniature croc clip. You can do something else while listening as the circuit goes through its paces. This can be particularly useful when working on timer circuits of one sort or another, when a long duty cycle gives lengthy intervals between changes in logic level. Staring at an LED is clearly impractical in such circumstances, but the changes of tone between high and low are easily detectable while you are otherwise productively engaged. It is also easier to detect patterns of output pulses this way. After listening to a repetitive stream of high and low notes at varying intervals for a short time, you can practically draw a timing diagram, whereas the pattern is much more elusive when watching LEDs.

Circuit Description

The circuit is straightforward and is shown in Figure 1. In essence it consists of two astable oscillators (a 'high' frequency one to indicate 'high' logic state, and 'low' frequency one to indicate a 'low' logic state), only one of which is activated at any time. In total the circuit needs nine gates – as the two 7400 ICs (IC1 and IC2) can contribute only eight, the remaining one is made from a transistor.

Consider the situation when the input signal is at a high TTL logic level, typically above about 2·4V. It is applied to both of the isolating stages, IC1 gate 1a and transistor TR1. Gate 1a inverts it, so a low level is present at enabling gate 1b, and therefore the 'low' astable is inhibited. On the other hand, the input voltage is passed through the transistor buffer stage to gate 2b, so the 'high' astable is enabled. The final mixer gate 2d therefore passes the 'high' frequency oscillation to the crystal earpiece, from where it can be heard.

Similarly, if the input signal is at a low TTL level, then the reverse happens. The 'high' astable is inhibited, the 'low' astable is enabled, and so the 'low' frequency tone is heard. Power for the tester is supplied from the 5V and 0V rails of the circuit under test.

If you are more used to CMOS logic ICs, it is important to note the different pinouts when breadboarding and constructing this (and indeed any other TTL circuit) using simple ICs. To drive this home, Figure 2 shows the respective arrangements for the CMOS and TTL equivalents.

Construction

The circuit was constructed on a small piece of stripboard. My loose-leaf Finished Circuits binder (I wish we were that organised – Ed!) tells me I made it in 1979, when I was still some years away from my first PCB. Anyway, such a simple project hardly warrants the effort required in designing a proper PCB – at least not unless you intend to make several of them!

It can be a very compact piece of test equipment, particularly bearing in mind

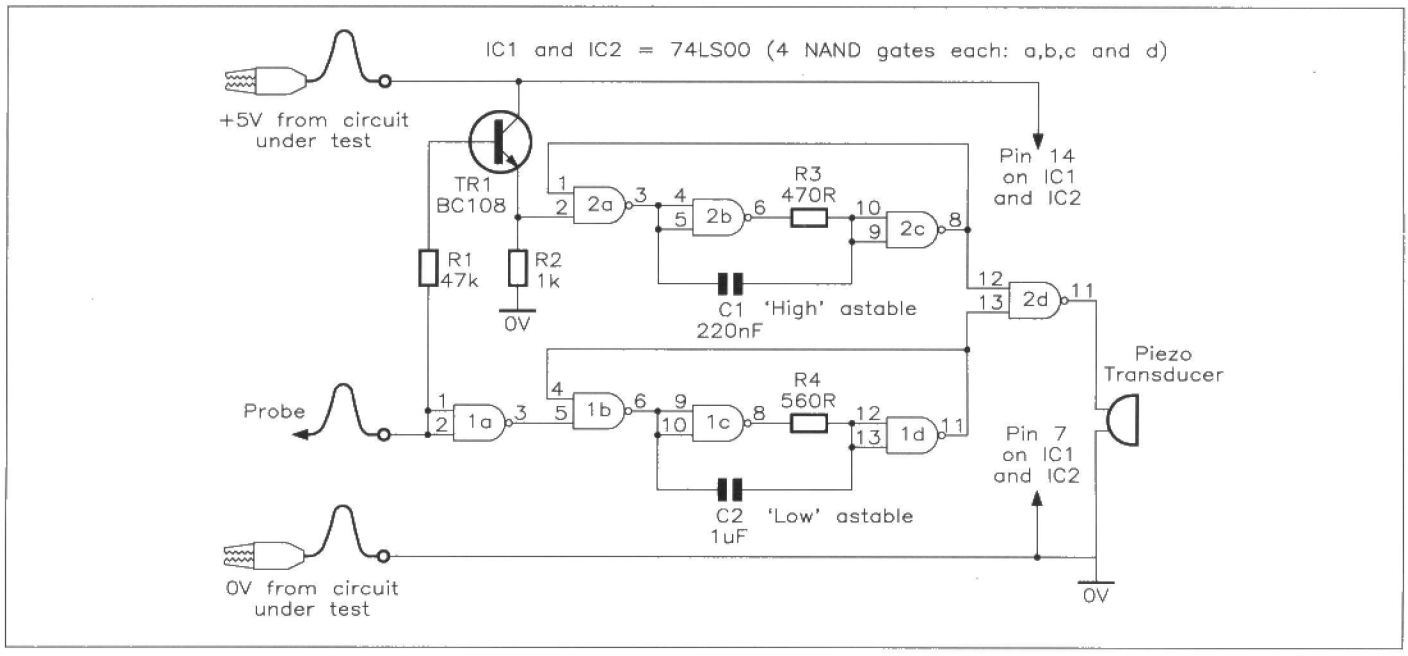
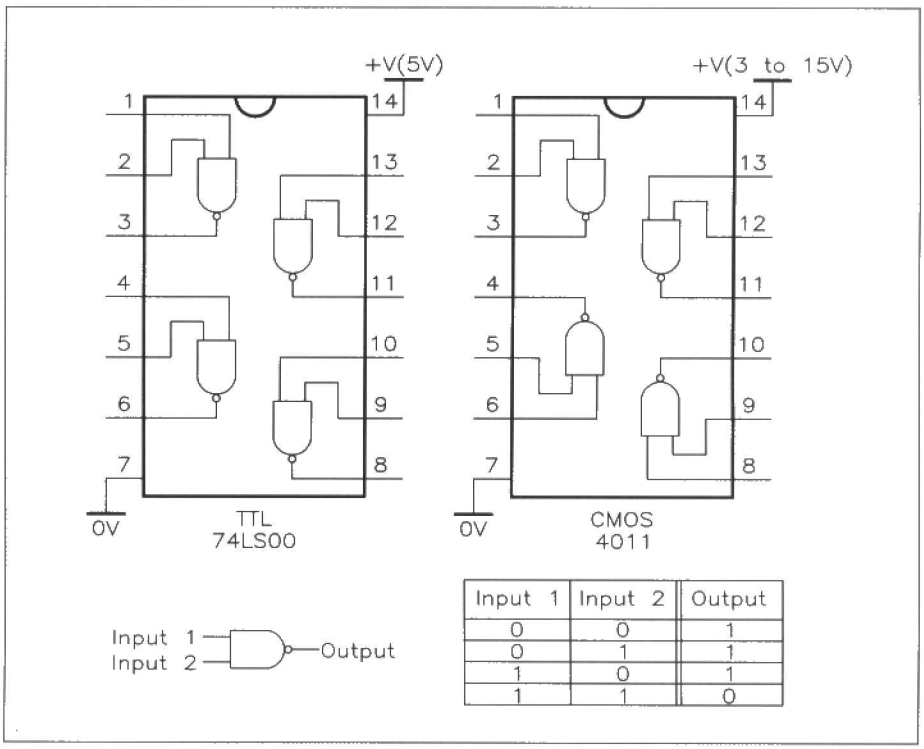


Figure 1. Audible TTL Logic Probe circuit diagram.

that no battery is needed. My own unit was housed in an empty 35mm slide case, as shown in the photograph. A couple of small blocks of soft wood were glued inside each end of the case, and a piece of thin plastic laminate used as a top cover, screwed into the wooden blocks, with the (roughly) 2in. x 1in. piece of stripboard resting snugly inside, and the crystal earpiece alongside a few carefully drilled holes. Any of a wide variety of Maplin's small plastic boxes would be a good choice for the case, and would only need holes drilled for the piezo sounder and the test leads – a particularly suitable housing would be FT31J.

Note

The circuit and information presented here must be considered as a basis for your own experimentation. No warranty is given for suitability in particular applications – Maplin cannot support this information in any way. However, where possible, we endeavour to check that information presented is correct, and that circuits will function as stated.



Input 1	Input 2	Output
0	0	1
0	1	1
1	0	1
1	1	0

Figure 2. Comparison of pinouts between TTL and CMOS quad NAND gate ICs, plus truth table for both.

AUDIBLE TTL LOGIC PROBE PARTS LIST

RESISTORS: All 0·6W 1% Metal Film

R1	47k	1	(M47K)
R2	1k	1	(M1K)
R3	470Ω	1	(M470R)
R4	560Ω	1	(M560R)

CAPACITORS

C1	220nF Mylar	1	(WW83E)
C2	1µF Polyester Layer	1	(WW53H)

SEMICONDUCTORS

IC1, IC2	74LS00	2	(YF00A)
Q1	BC108C	1	(QB32K)

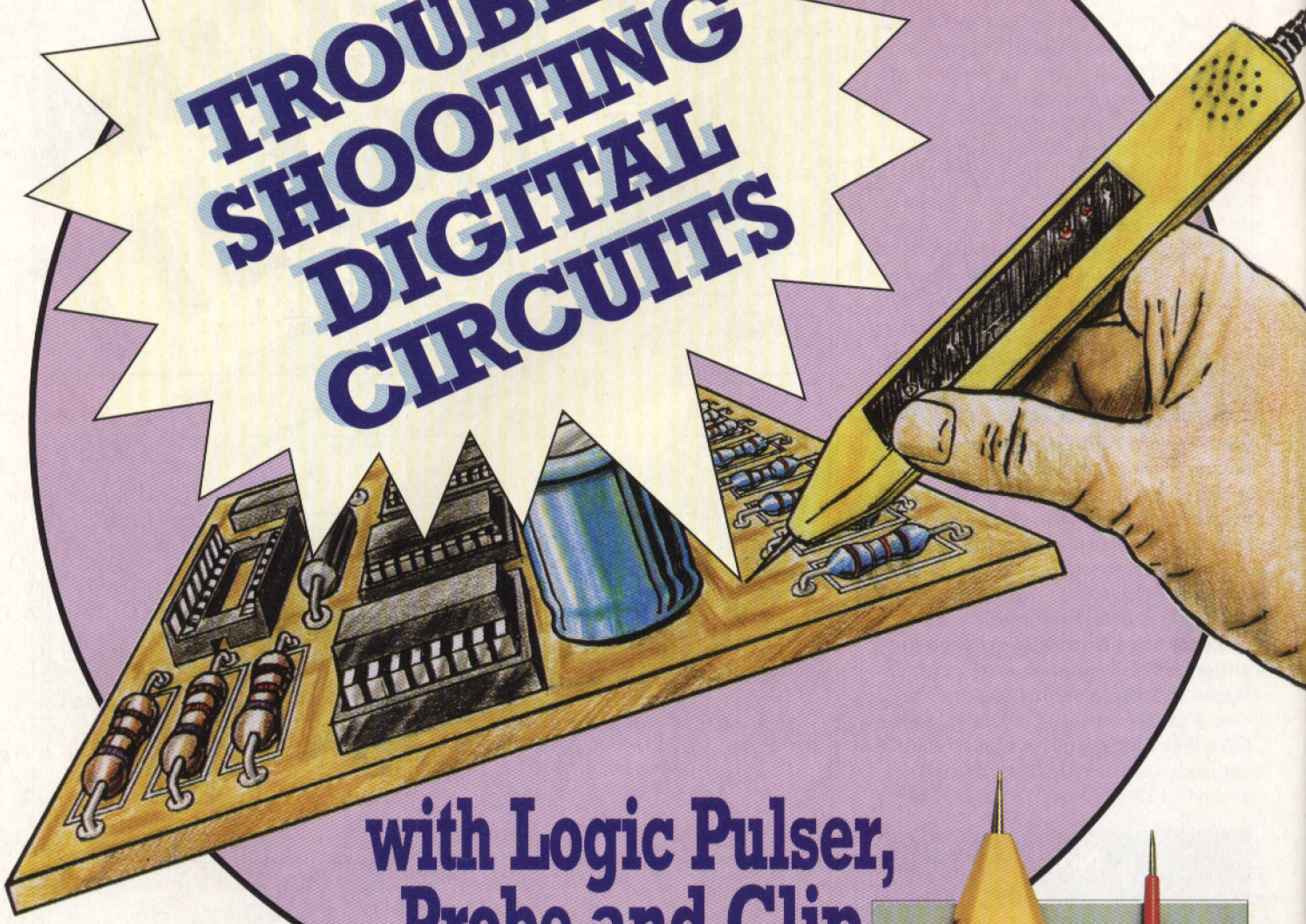
MISCELLANEOUS

	14-pin DIL Socket	2	(BL18U)
	Croc Clip Red	1	(FM37S)
	Croc Clip Black	1	(FK34M)
	Croc Clip Yellow	1	(FK35Q)
	Piezo Transducer 27/1·8	1	(YU87U)
	Case	1	(e.g. FT31J)
	Wire 7/0·2 Red	1 Pkt	(BL07H)
	Wire 7/0·2 Black	1 Pkt	(BL00A)
	Wire 7/0·2 Yellow	1 Pkt	(BL10L)
	Stripboard	1	(JP46A)

The Maplin 'Get-You-Working' Service is not available for this project.

The above items are not available as a kit.

TROUBLE-SHOOTING DIGITAL CIRCUITS



with Logic Pulser, Probe and Clip

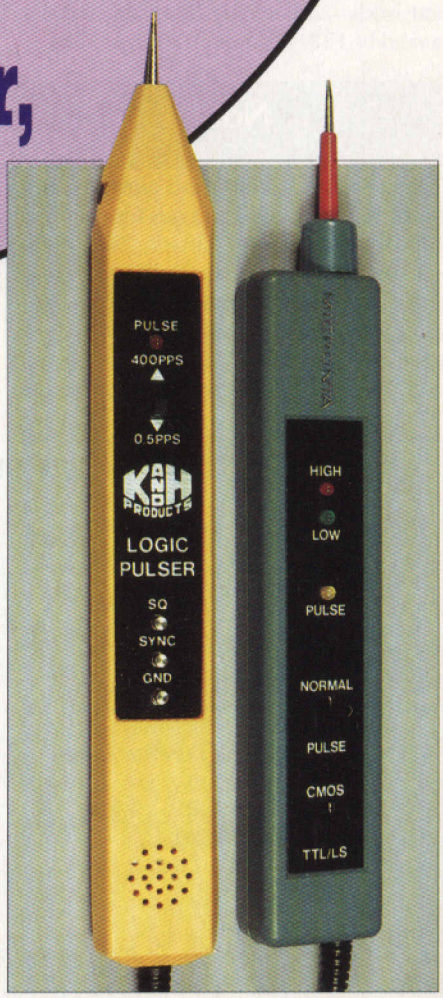
by Graham Dixey C.Eng., M.I.E.E.

The essential concept of digital logic is that it is solely based on a two-state system. That is to say, where in analogue circuits one may be expected to have to measure, from time to time, signal levels varying in an order of magnitude between the microvolt region and, perhaps, in tens of volts; in a digital logic system all that is necessary is to distinguish between two logic levels. These are known as logic 0 and logic 1 and, for a given family of logic devices, a voltage range is assigned to each logic level, within which the signal voltage can definitely be interpreted as being at one logic level or the other.

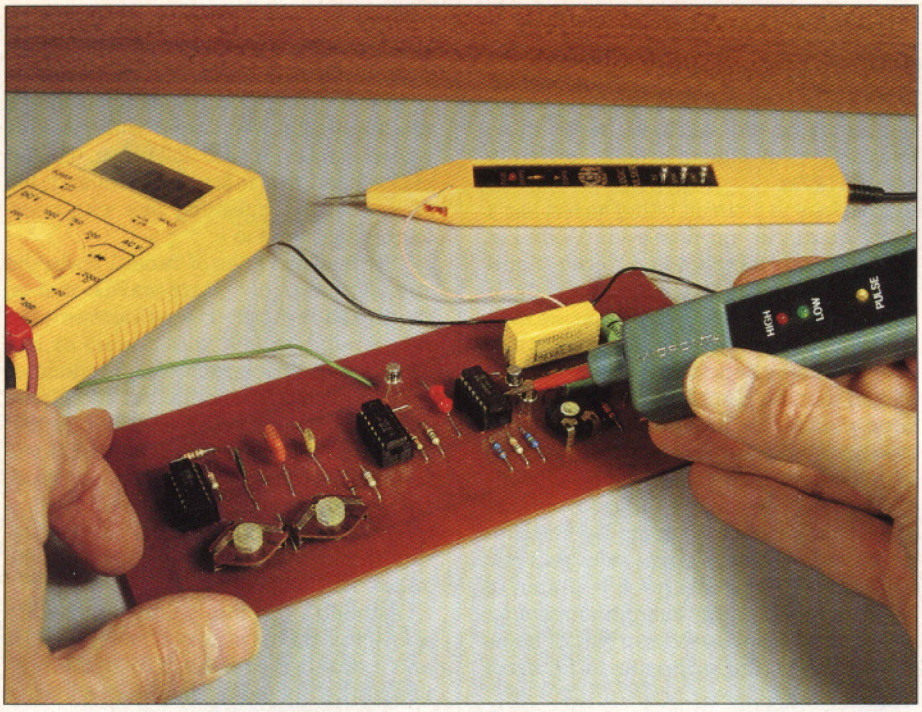
The Logic Families

For most purposes, these logic families fall into two distinct groups, if broadly, classed as TTL and CMOS, and a little explanation is in order here. Either of these terms is most often used to describe the technology of the device, which are sufficiently different to influence the way they behave. TTL is 'Transistor Transistor Logic', where bipolar transistors are the active elements in on-chip circuits which include resistors in their make-up. The two essential points about this are that firstly, each logic gate's input has a comparatively low impedance, and hence, secondly, a single TTL output can only drive a limited number of other TTL inputs reliably. This factor is called 'fan-out', and for TTL is typically 1:10 (1 output to 10 inputs).

This also applies to the older DTL (Diode Transistor Logic) scheme, where actual diodes were used as the inputs for each gate, before the modern technique of employing base/emitter junctions. DTL can be easily emulated with discrete components; diodes, transistors and resistors. In 'LS' devices (e.g., 74LS00 as opposed to 7400), 'LS' means 'Low-power Schottky', where Schottky barrier diodes are reverse connected across the base/collector junctions of all the transistors in the logic chip. These prevent the transistors saturating in



Left: A logic pulser. Right: A logic probe.



A typical logic probe in use.

CONDITION	WAVEFORM	LED INDICATION R	G	Y	SOUNDER
Logic 0	I / O	0	*	0	Low frequency
Logic 1	I / O	*	0	0	High frequency
Invalid	I / O	0	0	0	No tone
Logic 1 with negative pulses	I / O	*	0	F	Pulsing high
Logic 0 with positive pulses	I / O	0	*	F	Pulsing low
Square wave f < 200kHz		*	*	F	Pulsing Hi/Low
Square wave f > 200kHz		#	#	F	No tone

KEY: 0=LED Off, *=LED On, F=LED Flashing, #=LED May be on or off.

Table 1. Inputs to Logic Probe and responses.

the 'on' condition, enabling them to be switched faster, but with less supply current. Usually, LS TTL devices are made with the same switching speed as ordinary TTL, but operate with substantially less power consumption and, consequently, heat dissipation. Finally, because of the structure of the output stages, no TTL devices are able to output exactly 0V for logic 0, nor the whole 5V supply voltage level for logic 1.

CMOS, on the other hand, is 'Complementary Metal Oxide Semiconductor', the main feature of which is that all logic circuits are made up from combinations of an element which merely comprises a pair of MOSFETs (Metal Oxide Semiconductor Field Effect Transistors) of opposing types (complementary); one being a 'p-channel' type and the other 'n-channel'. (One pair of these in series across the supply and with their gates connected together form the simplest logic building block, an inverter.) In consequence, CMOS logic has a high input impedance due to the field effect operation of the FETs, so the 'fan-out' can be correspondingly greater than that of TTL, typically 1:50. Also, since no other passive components (resistors) are involved, many more CMOS logic elements can be packed into the same chip space otherwise occupied by TTL.

In addition, as a direct result of having a complementary FET pair at the output, CMOS is able to output logic levels which are much closer to 0V and the supply rail level than can TTL, for logic 0 and logic 1 respectively.

Thus, test instruments used in digital fault-finding will be designed to take account of this fact. This simplification is based upon the need to measure the 'amplitudes' of signals. Where actual observation of the digital waveform is required, then the techniques are similar to analogue measurements and a CRO (Cathode Ray Oscilloscope) of adequate bandwidth will be needed. If anything, the observation of clock waveforms in modern computers makes greater demands upon CRO performance. This is because, latterly, clock frequencies in such circuits are currently of the order of 25 to 33MHz; with higher clock frequencies, up to 66MHz is in sight or in actual use in some cases. Analogue measurements rarely involve bandwidths in excess of, say, 10MHz.

Frequency aside, a great deal of digital trouble-shooting can be carried out using two relatively inexpensive and easy to use test instruments. These are the Logic Pulser and the Logic Probe. They also have the merits of being small and compact, and needing no power supply requirements of their own. The small amount of power that they need is drawn from the circuit under test. This article will explain what facilities these instruments offer, and how to make use of them.

The Logic Probe

If, of the two instruments mentioned, you could afford only one, then the Logic Probe would be the right one to buy. A lot can be learnt from the circuit under test using just a probe. The Logic Pulser, on the other hand, tells us nothing unless a Logic Probe or CRO is used in conjunction with it. A typical Logic Probe, costing these days about £20.00, would probably have a specification similar to that given below.

It would be compatible with both TTL and CMOS logic levels, this being selectable by means of a slide switch.

It would have the following facilities: level detector; pulse detector; pulse memory; audio tone output with tone dependent upon the logic level

Taking the facilities listed above in turn:

Level Detector

Two LEDs are provided, one for each logic level. Typically, a Red LED would be used for logic 1 and a Green LED for logic 0. The actual colours are obviously not important, as long as the operator knows which is

Input impedance:	1MΩ
Minimum detectable pulse width:	30ns
Maximum frequency:	25MHz
Logic 0 threshold, TTL:	0·8V maximum
Logic 1 threshold, TTL:	2·3V minimum
Logic 0 threshold, CMOS:	30% maximum
Logic 1 threshold, CMOS:	70% minimum
Power supply range:	5V to 15V
Input protection:	200V AC/DC

Typical Logic Probe Specification.

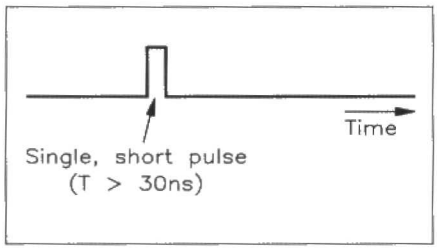


Figure 1. Short, isolated pulses will be latched by the logic probe.

which! There is also a third LED (which may be Yellow) marked PULSE, which will flash when a pulse train is being received. It is mentioned now because of its relevance in Table 1, which shows the indications given by the Logic Probe for a variety of input conditions.

Table 1 shows how each of the three LEDs responds to a particular situation. The obvious responses are that the Red LED is lit when the logic level observed is a '1' and the Green LED is lit for a logic 0 level; no other LEDs are lit in each case. This is the most basic use of the Logic Probe, and would test whether a logic chip had power supplied to it, or what the logic level was at a given point in a circuit, assuming that the latter level was fixed or changed only occasionally. Notice that the audio output is a high frequency tone for logic 1 and a low frequency tone for logic 0. This makes it possible to tell the value of a logic level without actually having to see the LEDs.

If a point in a circuit being tested has a level that is in 'no man's land', that is between the thresholds of logic 0 and logic 1, then no LEDs will be lit and there will be no audio tone. This is the same indication that would be given if the circuit had no power applied to it; thus the probe should then be placed in contact with the supply rail to check for power, unless there is some other reliable indication that there is power on the circuit.

The next two lines of Table 1 cover the situa58tions where the logic level is predominantly at either logic 1 or logic 0 but, superimposed on this level, is a train of short pulses of large enough amplitude, driving the signal level down into, or up to, respectively, the opposite logic level region.

Where the level is essentially logic 1 with negative pulses superimposed, the Red LED will be lit, the Green LED will be out, and the Yellow LED will be flashing (to indicate the presence of a pulse train); the audio tone will be pulsating with a predominantly high frequency sound to it.

Where the opposite situation is found, that is a logic low signal with positive pulses, the Green LED will be on, the Red LED off and the Yellow LED flashing; the tone will be a pulsating one with a low frequency sound to it.

The final two lines of Table 1 cover the specific cases of square-waves, that is, where the level alternates between the two possible values, with a more or less equal mark/space ratio. For frequencies up to about 200kHz, both Red and Green LEDs will flash at a perceptible rate and with even intensity; the Yellow LED will flash and a pulsating tone will be heard, with two clear alternate high and low frequencies. Above 200kHz, the only indication that can be relied upon is that the Yellow LED will flash.

Although the indications described above rest on the states of the three LEDs and a two-tone sounder, a lot of information can be obtained. This information can be categorised as follows:

(a) Tests for static levels in a circuit, e.g., chip power supplies and outputs of gates, logic levels on flip-flop pins, counters and registers (in the static state) – using just the Red and Green LEDs and/or the audio sounder.

(b) Tests for the presence of pulse trains and indicates whether the level is predominantly high or low, by means of the LEDs and/or the audio sounder.

(c) Distinguishes the presence of square-wave signals, or signals with a near unity mark-space ratio, by the relative brightness levels of the Red and Green LEDs.

At very low frequencies, e.g., 1 to 10Hz or so, the Red and Green LEDs will be seen to alternate quite clearly. At much higher frequencies, this effect disappears and both LEDs appear to be lit together.

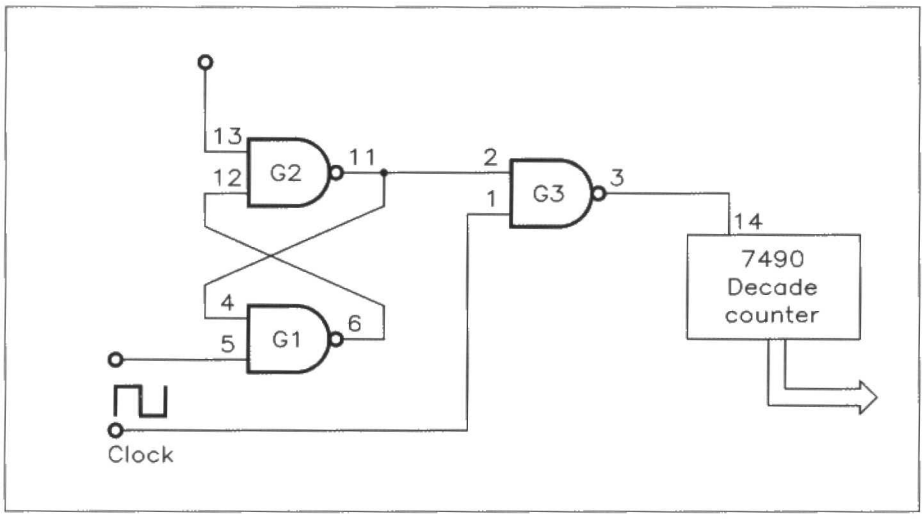
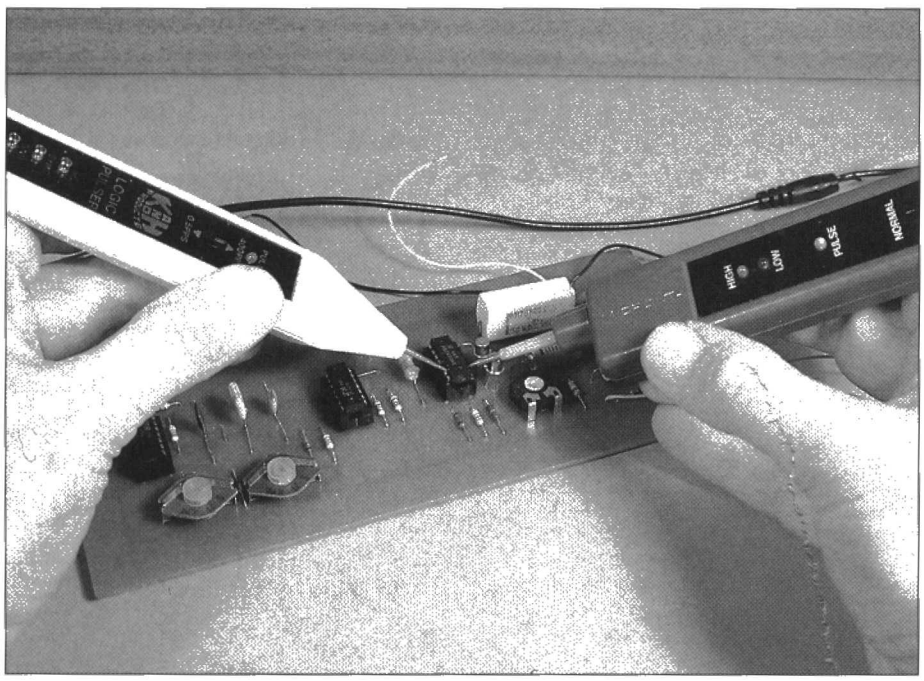


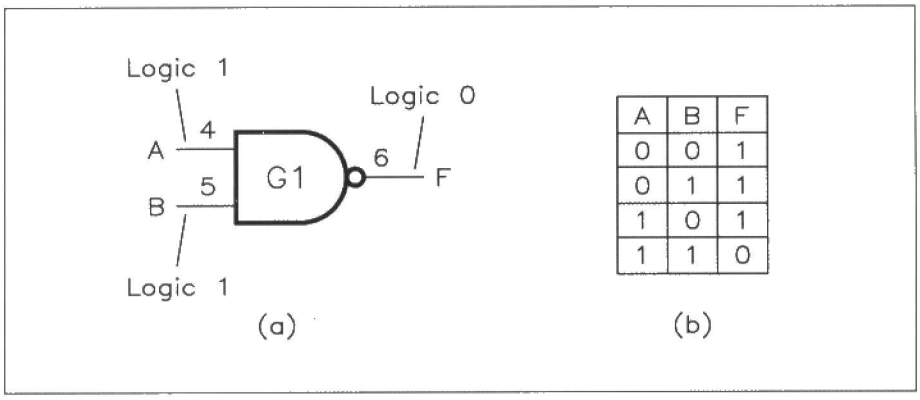
Figure 2. A latch and counter with gated clock.



A logic pulser being used in conjunction with a logic probe.

The Pulse Memory

The Yellow LED is latched by a logic level change at the input when the associated function MEMORY is selected. This is done so by moving a two-position switch, typically marked MEM/PULSE or MEM/NORMAL, to the MEM position. This is a useful facility that allows the capture of an event that would be far too fast for the human eye to record. For example, in Figure 1, a very short pulse appears, that would cause only the shortest of blips on the Red LED; it would simply go unnoticed. Provided that such a pulse is not less than 30ns in length, it will set the memory latch and the Yellow LED will turn on, giving a clear indication that a change of level or a pulse occurred. Which will normally be evident from the context of the circuit under investigation and by the states of the Red and Green LEDs. If there are two or more successive pulses, only the first will affect the memory latch; the others will be ignored. The latch can be reset by moving the slide switch from the MEM position and back again. The latch can be tripped by either a momentary negative excursion from logic 1 or a similar excursion in the positive direction from logic 0. Either negative or positive pulses can be captured.



A	B	F
0	0	1
0	1	1
1	0	1
1	1	0

Figure 3. Testing a NAND gate (1).

The Logic Pulser

Similar in appearance to the Logic Probe is the Logic Pulser; the price is about the same too. It is, in effect, a miniaturised pulse generator, which outputs a very short pulse with high current capability at one of two preselectable frequencies, or at a rate that is synchronised to some external clock source.

The high current capability of the pulser allows inputs to be forced through logic level changes without the need to remove the IC from the circuit. In spite of the high current possible, the short duration of the pulses ensures that the power dissipated at the test point has no harmful effects on the component being tested. A typical operational specification is as follows:

As with the Logic Probe, the Logic Pulser takes its power from the circuit under test.

Logic Pulsers usually have three clip-on terminals on their 'front panel'. One is the synchronising input referred to above, the second is the ground (0V) connection, and the third is a square-wave output at the selected frequency.

There is a good reason for having a choice of two frequencies. The lower one of 0·5Hz is ideal for observation by the human eye, a pulse at a time. The higher frequency of 400Hz allows a stable display to be obtained on a CRO.

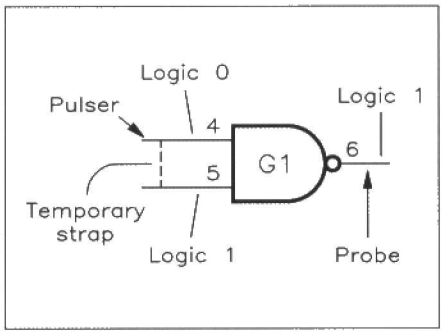


Figure 4. Testing a NAND gate (2).

Sync. Input impedance:	1MΩ
Pulse rate:	Switchable 0·5/400Hz
Pulse width:	10µs
Output current:	100mA
Power supply range:	5 to 15V

Typical Logic Pulser Specification.

Trouble-Shooting Logic Gates

Figure 2 shows part of a logic circuit in which there are three NAND gates, G1, G2 and G3. The output of the latter drives the clock input of a decade counter (7490). Gates G1 and G2 form a latch, whose function is either to enable or disable the counter via gate G3. When the latch is in the reset state (pin 11 = 0), the counter is disabled because the output of G3 will be permanently high, so preventing pulses on pin 2 of G3 from reaching the counter input. This arises because when one input to a NAND gate is at logic 0, the output of that gate will be at logic 1 irrespective of the logic state of other inputs to the gate. However, when the latch is in the set state, the logic level on pin 11 will be logic 1, as will be the level on pin 2 of G3, and the output of G3 will alternate at the clock rate. The latch is reset when a logic 0 is applied to pin 5 of G1, and set when a logic 0 is applied to pin 13 of G2.

So much for the theory, but how can a Logic Pulser and Probe be used to check the operation described above? What logical sequence of steps would we adopt?

Right, power on first of all. Now apply the pulser, with its frequency set to 0·5Hz, to the input marked CLOCK in Figure 2, then apply the probe to pin 3 of G3. Does the probe indicate the presence of a train of pulses?

Assume that the answer is "yes": this means that G3 is enabled; thus the latch ought to be in the set state. In that case, we should find that pin 11 of G2 should be at logic 1. If the probe is transferred to this pin, it is possible to verify whether this is so or not. Assuming that it is correct, then that part of the circuit has been shown to function correctly. What is not yet known is whether the latch can be flipped back and forth between its two states by applying logic 0s at its inputs. Since we have found that the latch is in the set state, the logical thing to do is to attempt to reset it. To do this, we should place the probe on pin 11 of G2 (to observe the result), and place the pulser on pin 13 of G2. This will force this input to logic 0 and, if the latch is functioning correctly, the logic level at the output, pin 11, will change state, by going down to logic 0. If it does so, then the latch can obviously be triggered from the set state into the reset state. Leaving the probe on pin 11, move the pulser to the input pin of G1 (pin 5); the latch should now be seen to go back into the set state, pin 11 going high. If it does so, then fine, but there is one last, overall, check that can be carried out. Place the pulser on the CLOCK input and the probe on pin 3 of G3. A pulse train, at the pulser frequency, should be observed. Momentarily move the pulser to pin 13 of G2 (thus resetting the latch) and then back to the CLOCK input. The signal at pin 3 should no longer be a train of pulses but a steady logic 1 level. Repeat this operation on pin 5 of G1, to set the latch again, and note that the pulse train reappears. If all of these indications are correct, you can be sure that you have a fully functioning circuit.

Well, if you went to the trouble of breadboarding the circuit of Figure 2 (and let's be honest, it wasn't a big job to do so), you should now have the feel of using these two basic test tools. What we now need to consider is what we should have done if we had found that the circuit did not respond correctly at any stage of testing it. One way to approach this is to assume a particular fault on the circuit. What type of faults might we expect to find in practice?

In the majority of cases, faults occurring in digital circuits will be found to be of the 'stuck-at-0' (s-a-0) or 'stuck-at-1' (s-a-1) variety, that is, a short-circuit between a pin on the IC and either the 0V line or the positive supply rail, due to an internal fault in the chip. Other possible faults include short-circuits between adjacent pins or adjacent tracks, or open-circuit pins (again an internal failure, but may also be due to bad IC sockets). To test a possible faulty gate, the inputs of the gate need to be energised by the Logic Pulser, and any output changes noted with the Logic Probe. A logical sequence of such tests will pin-point the faulty pin or pins of the IC. The procedure might be as follows:

Suppose we wish to test gate G1 and that, at this moment, the logic levels on the gate are as shown in Figure 3(a). Thus, pin 4 is at logic 1, pin 5 is at logic 1 and pin 6 is at logic 0. This conforms to the truth table for a NAND gate, as shown in Figure 3(b) – the output is logic 0 only when both inputs are at logic 1. If the pulser is now applied to one of the input pins, either pin 4 or pin 5, then the output pin (pin 6) should go high momentarily – just a quick flicker on the PULSE LED of a Logic Probe applied to this pin.

Suppose that, when the pulser is placed on pin 4, a change is observed at pin 6; does this prove that gate G1 is healthy? Not necessarily, there could still be a fault on the other pin, pin 5. To test this, we move the pulser to this pin and note whether a change of level occurs at pin 6. If it does, then the gate is healthy; if it doesn't, then pin 5 must be stuck at logic 1. The fault cannot be on pin 6 itself, otherwise no response would have been seen at this pin when pin 4 was pulsed. Now consider a more general case.

Testing a Logic Gate

Suppose that it is suspected that the fault lies in a particular gate, such as gate G1 in Figure 4. Assume that first of all we use the Logic Probe to measure the logic levels at the input and output pins, and that the following result is obtained – this result is quite arbitrary but the basic procedure remains unchanged whatever is assumed:

Pin 4 = 0; Pin 5 = 1; Pin 6 = 1

This combination of input and output logic levels agrees with the truth table for a NAND gate. If any difficulty is experienced in remembering the truth table for any gate, in many cases it helps to remember just one significant line. For the NAND gate, this is as follows:

"The output of a NAND gate = logic 0 ONLY when ALL inputs are at logic 1."

From this it follows that, when any of the inputs is at logic 0, the output is always at logic 1.

The logic levels measured, although they agree with the truth table, do not prove that the gate is fully functional. For example, there are three distinct fault possibilities that would allow the above measurements to be obtained. These are:

(a) Pin 4 is 'stuck-at-0'
(b) Pin 5 is 'stuck-at-1'
(c) Pin 6 is 'stuck-at-1'

We have to check whether any of these cases exist. We can do this by trying to force each pin to change in response to an appropriate input stimulus.

For example, if we apply the Logic Pulser to pin 4, this will attempt to force this pin to change state; if it can do so, then the output should go momentarily from logic 1 to logic 0 and then back again – indicated by a blip on the PULSE LED of the Logic Probe which we have placed on pin 6 to observe the result. There are obviously two possible results:

(a) pin 6 changes state, in which case there is no short-circuit on either pin 4 or pin 6.

(b) pin 6 does not change state, in which case there is either a short-circuit on pin 6 (to +5V) or there is a short-circuit on pin 4 (to 0V).

Consider possibility (a) first of all:

There may still be a short circuit on pin 5, which would be between this pin and the positive line. Placing a pulser on pin 5 and a probe on pin 6 will prove nothing, because even if we can force pin 5 to change state, pin 6 will not do so because pin 4 is at logic 0 and this alone ensures a logic 1 output, irrespective of the logic level on pin 5. How can we get round this problem? If pin 5 is stuck at logic 1 (by a short-circuit to the positive supply line), then pulsing this pin should have no effect. Therefore, we place BOTH the pulser AND the probe on pin 5 and see whether there is any response. A positive response here shows that pin 5 is not s-a-1.

Now consider possibility (b):

Here we have an indication of a fault, one of two possibilities. Pulsing pin 5 will not cause a change at pin 6, even if there is no fault on pin 5 (basic NAND logic). We can test for the two possible faults as follows:

Test for pin 4 short-circuit to 0V: strap pins 4 and 5 together, and place both pulser and probe on this connection. If pin 4 is short-circuit to 0V, all of the pulser current will flow into this short-circuit and no response will be registered on the probe.

Test for pin 6 short-circuit to +5V: with pins 4 and 5 strapped together as above, place the pulser on this connection and the probe on pin 6. If, now, there is no response at pin 6, then the short-circuit is between the latter pin and +5V.

This type of eliminative approach can be applied to any type of logic gate, irrespective of type or the number of inputs. All that one needs to know is its truth table.

Testing Sequential Logic Circuits

This is even easier than testing gate combinations for faults. The counter or shift register is essentially a dynamic circuit, changing state frequently under the control of a clock signal. Such a circuit is shown in Figure 5, which also includes some logic gating. The circuit can be driven from one or other of two alternative clock inputs, one being a manual input (MAN), supplied from a push-button switch, the other an AUTO input from a clock oscillator (not shown). There are several ways of checking the correct operation of this circuit.

In the first case we select the AUTO input with the MAN/AUTO switch and, assuming that the clock oscillator is active, use only the logic probe to follow the path of the clock signal as far as the input (pin 14) of the 7493 binary counter (IC5). Several test points are marked in Figure 5, the first being TP1 at the output pin of the clock oscillator (IC1). We could start here or we could place the probe on TP5. If we do the latter and find a stream of pulses at this point, then we know that no fault exists up to this part of the circuit, unless it lies in the MAN input side. However, if there are no pulses at TP5 then we need to look earlier in the chain. A technique, known as 'the half-split method', is useful in that we always look at a point midway along the suspect chain of components, thus eliminating half of the circuit with any one test.

In this case, we place the probe at TP4. If there are pulses at this point, then the circuit to the left of TP4 is working correctly. If there are no pulses at TP4, then the fault is prior to this point. This procedure is continued until the fault is localised. As an example, assume that the pulses are found at TP2 but not at TP4. The second JK flip-flop, IC2b, is wired in the toggle mode (J and K both at logic 1), so it ought to change state on every clock pulse on its input pin 5. First we must establish whether there are any clock pulses here; presumably there are, since only an open-circuit between TP2 and the clock input of IC2b could prevent there being any, a possibility but not one of the more likely ones. The

Continued on page 63.

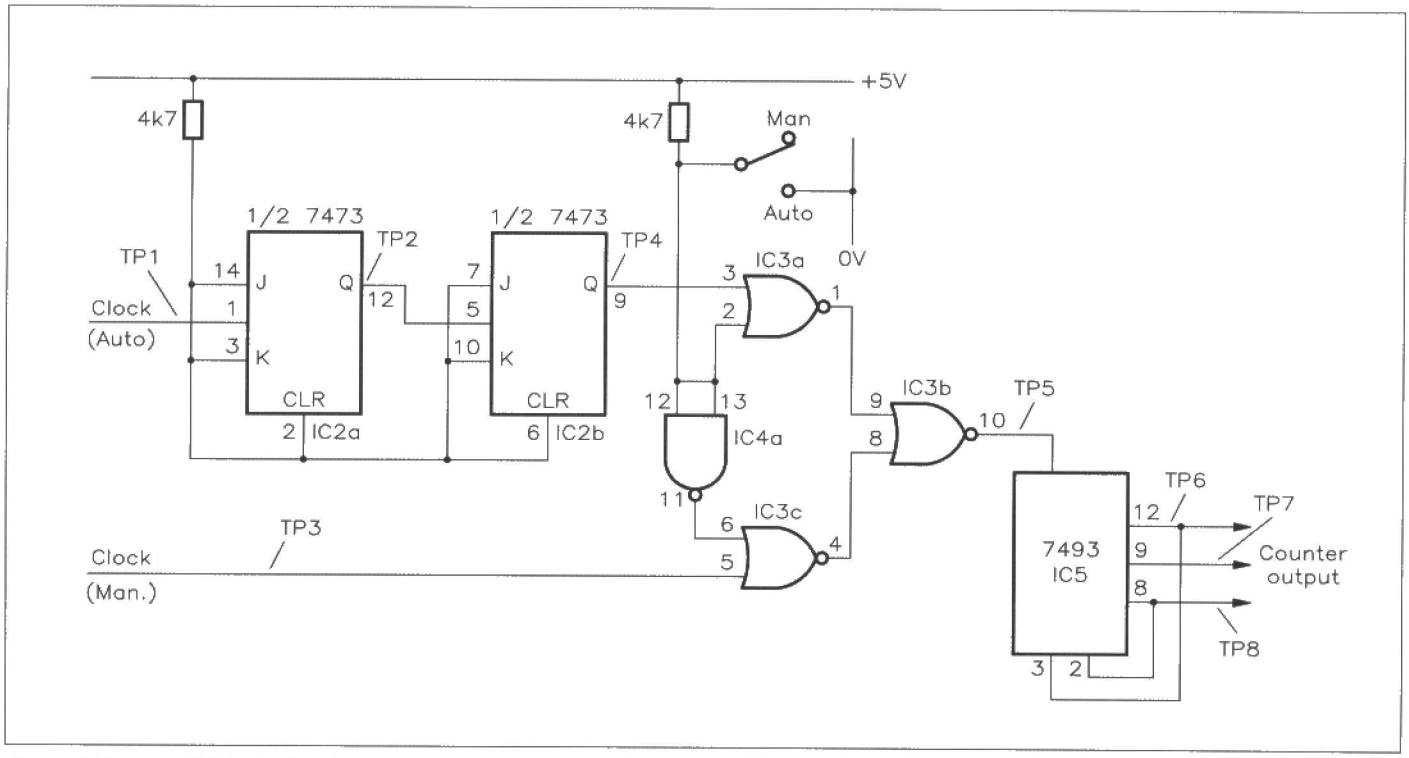
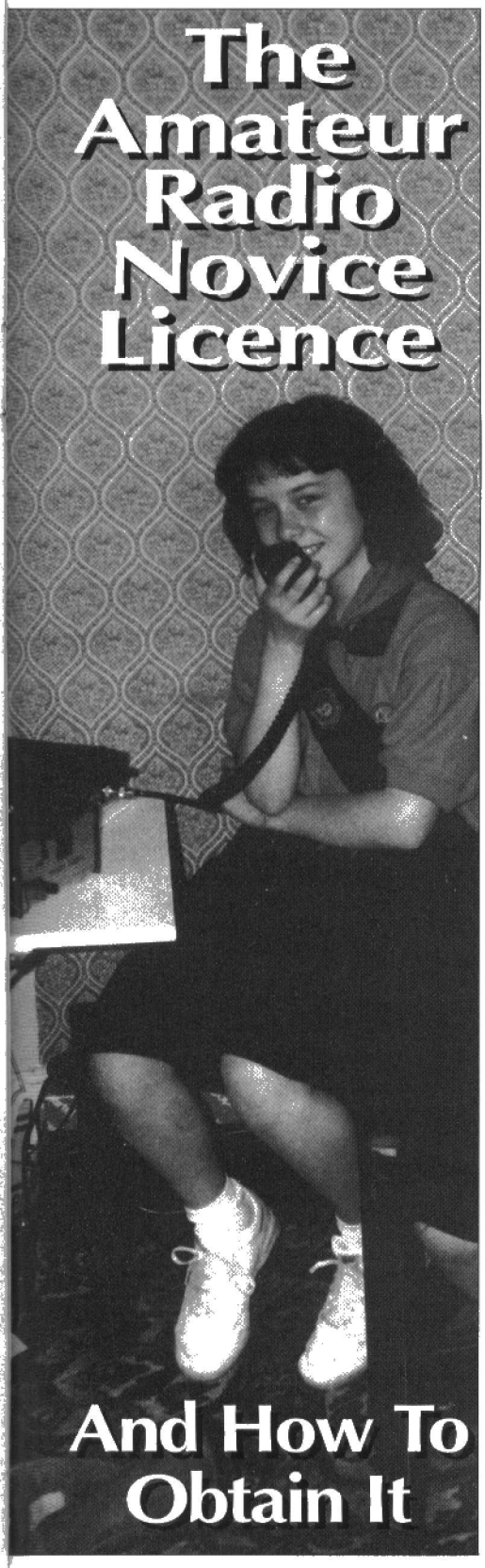


Figure 5. A sequential logic circuit.

The Amateur Radio Novice Licence



And How To Obtain It

by Ian Poole G3YWX

Amateur radio is a hobby which gives millions of people around the world many hours of enjoyment. Through the hobby it is possible to make friends on the other side of the globe or chat to someone around the corner. Some people like to make contacts with as many countries as possible. From the large countries, like the USA or Russia, to much smaller islands, there are over three hundred to contact.

The hobby can also be creative. Many radio enthusiasts build and even design their own equipment. It gives a great sense of achievement to make a contact over hundreds of miles, or possibly thousands of miles, using equipment which you have built. Whilst only a few build all their own equipment many people build at least some – it may be a small transmitter or a receiver, or it could even be a piece of test equipment. Whatever it is, the sense of achievement is there.

The hobby can be used to help others. Often, when a disaster has struck in a country, radio amateurs have provided the only form of communications with the outside world. Although it is unlikely that the same situation might occur in the UK, amateurs are allowed to use their equipment and skills to help the emergency services. They have provided a valuable service, by doing this, on a number of occasions in recent years.

Transmitting

Whilst many people enjoy listening, most will want to be able to transmit to be able to make the most of this fascinating pastime. However, to do this a licence is required. Until recently this meant passing an examination called the Radio Amateurs' Examination (RAE). This is administered by the City and Guilds, and the syllabus covers basic radio theory, operating procedures and licence conditions. On its own this would enable a class B licence to be obtained for operation on the amateur bands above 30MHz. For access to all the bands, including those below 30MHz, a Morse test of 12 words a minute sending and receiving speed is required for the full class A licence.

Unfortunately, many people who would like to hold a transmitting licence see these examinations and tests as a very large hurdle. In addition to this, applicants have had to be over 14 years of age, and this has ruled out many younger enthusiasts. To encourage more people into the hobby, the novice licence was introduced at the beginning of 1991. It adopted a completely new approach, concentrating on 'learning by doing'. For operation using the novice allocations above 30MHz, a practical course must be successfully completed. Then the Novice Radio Amateurs' Exam (NRAE) has to be passed. Fortunately no further study is required for the exam, as it is based on the course. Both of these are easier than the ordinary RAE, and this opens the hobby up to a wider number of people.

If operation on the novice bands below 30MHz is envisaged, then a Morse test must be passed as well. However, this is only 5 words a minute sending and receiving, and it is tailored to the requirements of the novice licence.

Above: communal project construction during a novice training course.
Left: learning to transmit and receive morse code.
Top Left: telephony above 30MHz.

i.	Be Safe
ii.	The Radio Amateur's Code
1.	The Colour Code
2.	First Soldering Exercise. Test Set No. 1
3.	Soldering Exercise No. 2
4.	Discover Ohms Law – 1
5.	Codes and Abbreviations
6.	More Codes and Abbreviations
7.	Audio Frequency Amplifier Project
8.	Setting Up a Contact
9.	Soldering – Test Set No. 2
10.	Build a Log and Design a QSL Card
11.	A Look at Aerials
12.	Putting a Multimeter to Work
13.	Measuring Resistance
14.	Measuring Direct Current
15.	Power
16.	Propagation
17.	The QSL Bureaux – and Other Aids for Radio Amateurs
18.	AC and Frequency
19.	Tuned Circuits
20.	Demonstrate Ohms Law using Test Set 2
21.	Fit 13 Amp Plug to a 3 Core Mains Lead
22.	The Spectrum
23.	Fit a PL259 Plug to a Coaxial Cable
24.	Fit a BNC Plug to a Coaxial Cable
25.	Block Diagrams – Receivers
26.	Block Diagrams – Transmitters
27.	Harmonics
28.	Test Set 2 – With Diodes and Transistors
29.	Learning the Morse Code – With Help From Hilary G4JKS
30.	Getting Ready for a Morse Contact
31.	EMC
32.	Power Supplies

Table 1. Novice Course Work Sheet Titles.

The Course

The novice training scheme is organised by the RSGB, and taught by a large and enthusiastic volunteer force of instructors around the country. To ensure that high standards are maintained, each instructor has to be approved by the RSGB every year.

Courses are available throughout the country, and each area has its own senior instructor to oversee the scheme. Groups of people taking the course are kept to a small scale, typically a maximum of four, unless further instructors are available. This ensures that sufficient individual attention can be given to everyone.

The course is planned to last about 30 hours and takes place over a span of 12 weeks. However, instructors are strongly encouraged to tailor each course to the students on it. For example, if particular interest is shown in one topic then there is sufficient flexibility to allow extra time to cover it in greater depth.

Often the course will be held in an instructor's own home, otherwise some other suitable premises, like a radio clubroom or scout hut can be used. This helps to keep the cost down. In fact there is no charge for the course itself, although the instructor will ask for incidental costs to be covered. These will be stated before the course begins.

The aim of the course is to teach the syllabus in a practical and interesting way. To accomplish this a set of work-sheets have been compiled. They cover all the topics required by the syllabus, everything from a number of small constructional projects to operating procedures, Morse, and propagation, as shown in Table 1. By setting up the course in this way the emphasis has been placed on learning by actually doing things.

The Exam

Once the course has been successfully completed, a completion slip is issued by the RSGB. In addition to this, a certificate can be obtained from them at a nominal cost of £2.50. The next stage is the exam itself. This is organised by the City and Guilds, and is held at a number of centres around the country. The course instructors will have details about the local centres.

The cost of the exam itself is £9.65, but there is also an administration fee for the examination centre. This will vary from place to place, so check what it is with the local centre.

The exam consists of 45 multiple choice questions to be answered in 1 hour and 15 minutes. Questions are set on topics which will have been covered in the course. There are some about the licencing conditions, but to help answer them a copy of the licence schedule is provided during the exam. This is because the licence will be to hand when operating a station, but the student must know how to use it.

After the exam is completed, the results do not take long to arrive. Generally the City and Guilds expect to have them available four weeks after the exam.

Morse Test

Whilst it is possible to obtain a licence without having to take a Morse test, some will want to go on and take it so that they can use the HF bands. As the speed required for it is only 5 words per minute, most people will find it quite easy to master.

There are a great many ways to learn the Morse Code. Often radio clubs will run courses, especially if they have a novice course associated with them. Alternatively a local radio amateur may be able to help out. In addition the RSGB have prepared a training tape called 'Morse Code – Stage 1' which can be a great help. For home practice, electronic Morse tutors can also be used. The RSGB also provide slow Morse practice transmissions on a number of the amateur bands at a variety of times.

Morse testing is organised by the RSGB, and they can supply an application form together with full details. There are test centres in most of the counties in the UK as well as in the main Scottish Regions and main islands. Each centre holds a test about every two months, although, by applying to a neighbouring area, it is often possible to arrange a test within about two weeks.

The test consists of two sections. There is a three minute section of sending the code, and then six minutes receiving. During each section letters, characters and procedural characters are all included, so that a real contact is simulated.

Frequency Band (MHz)	Types of Transmission Permitted
1·950 to 2·000	Morse, Telephony, RTTY, Data
3·565 to 3·585	Morse
10·130 to 10·140	Morse
21·100 to 21·149	Morse
28·100 to 28·190	Morse, RTTY, Data
28·225 to 28·300	Morse, RTTY, Data
28·300 to 28·500	Morse, Telephony
50·620 to 50·760	Data
51·250 to 51·750	Morse, Telephony, Data
433·000 to 435·000	Morse, Telephony, Data
1240·000 to 1325·000	Morse, Telephony, RTTY, Data, Facsimile, SSTV, FSTV
10 000·000 to 10 500·000	Morse, Telephony, RTTY, Data, Facsimile, SSTV, FSTV

Table 2. UK Amateur Bands.

The Licence

Having obtained all the requisite pieces of paper, the licence can be obtained. This costs £15 a year for those over 21, but for those under this age it is free.

Like all other amateur licences, callsigns are issued for novices. They start with the figure 2, which is then followed by a letter to indicate the country; E for England, M for Scotland, W for Wales, I for Northern Ireland, D for the Isle of Man, U for Guernsey, and J for Jersey. The next character in the callsign is another number which indicates the class of the licence. Figures 0, 2, 3, or 4 are used for Class A licences and 1, 6, 7, or 8 are used for a Class B licences. For example, a station with the callsign 2E0ZZZ would indicate a Class A licence in England whilst 2D1XXX would indicate a Class B licence in the Isle of Man.

On the Air

There is a surprising amount which the novice licence allows. It has been designed to allow as many types of operation as possible so that novice licence holders can experiment in the same way that holders of standard licences can.

A prime example of this is the provision that the frequency allocations ensure that many different aspects of the hobby can be covered. Above 30MHz there is access to the FM simplex and repeater channels on 70 centimetres. In addition portions of 50MHz are available, making possible long distance

communications during periods around the sunspot maximum. Unfortunately the most recent sunspot activity has passed, but there is still a lot of interest on this band until the next one occurs. Higher frequency allocations are also given, and although there is less activity on these bands, they give a large amount of scope for experimentation.

For the HF enthusiast with a Class A licence, operation is possible on many of the bands in this portion of the spectrum. This gives the possibility of worldwide communications along with all the excitement of the HF bands.

Apart from the more usual forms of communication like telephony and Morse, data communications are allowed on many bands. This is an area of the hobby which is growing very fast these days. Many amateurs link their computers up to radio equipment, allowing sophisticated forms of data links to be set up. Packet radio is the most common. With this a large number of facilities are available, including other stations relaying signals to enable messages to be transmitted over longer distances. A system of mailboxes has been set up, and using this facility a message can be sent to a station via the local mailbox. Once received it will be stored until it can be relayed via the packet mail system to the destination mailbox. It will then be stored until it is collected by the recipient.

The maximum power level allowed under the terms of the novice licence is 3W output, or 5W DC input to the last stage of the transmitter. This is quite sufficient to make many very interesting contacts.

Success Story

The first licences were issued on 25th July 1991 when seven young people were presented with their licences by John Redwood who was the Department of Trade and Industry Corporate Affairs Minister. Since then the number of licences has grown quite rapidly. By April 1992 more than 900 course pass slips had been awarded, and along with these a large number of licences have been issued. This means that many more people in this country are now enjoying the hobby of amateur radio than ever before!

Addresses

Radio Society of Great Britain, Lambda House, Cranborne Road, Potters Bar, Hertfordshire, EN6 3JE.

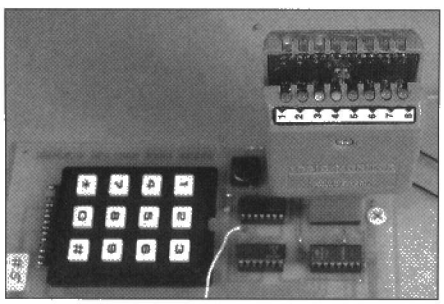
Troubleshooting Digital Circuits continued from page 60.

probe can be used to check that pins 6, 7 and 10 of IC2b are at logic 1 (which they must be), as shown in the circuit diagram. Assuming that they are, then the fault lies at either the output pin of IC2b, or the input pin (pin 3) of IC3a. Finding which of these two ICs is faulty demands either the use of a current tracer or a trial substitution of one chip or the other (a 50/50 chance). If the IC is socketed, then the latter option is the easier. If the IC is soldered into the board, substitution is a less happy task and the use of a current tracer (assuming that one is available) will pin-point the short-circuit quite quickly.

The above method has made use of the logic probe as a signal tracer, relying upon the clock signals themselves. In the MAN mode, these signals are obtained by operating a push-button switch. It is more convenient to ignore the switch and use the logic pulser as the source of clock signals, injecting these at TP3. Henceforth, the procedure becomes exactly the same as described above.

The Logic Clip

Also known as a 'glomper clip' (where do they get these names from?), this little gadget is like having a handful of logic probes, though in a much more compact form. In use it clips over the IC and connects to all of the pins of the IC at the same time. Each contact is the input point to a separate logic level monitor; thus, a 16-pin logic clip has 16 built-in monitors, each with its



A logic clip attached to an IC.

own driver and LED. One such gadget owned by the author is made by Global Specialties, and is known as their Logic Monitor type LM-1. This is a 16-pin device that is able to give a simultaneous display of the static and dynamic logic states of DTL, TTL, HTL and CMOS 14-pin and 16-pin ICs. The input threshold for this device is 2.0V ± 0.2V, at which point the appropriate LED turns on. Therefore a positive indication is only given for the logic 1 state. Signals below the threshold will not register; these include the logic 0 level, undefined states and loss of power. The latter can, of course, be verified by checking the chip supplies separately.

The LM-1 incorporates a built-in, power seeking gating network, that locates the most positive and negative voltages applied to the IC under test. It then feeds them to the internal buffered amplifiers and LED drivers. In this way, the logic clip is powered from the test circuit. The current consumption will obviously depend upon the supply voltage and the number of LEDs that are on at any one time. In the worst case, with a 10V supply and 15 LEDs on, the current taken from the supply could be as high as 200mA. Obviously this must be borne in mind when attaching the logic clip to the circuit board. However, in a more moderate case, where the supply is only 5V, all 15 LEDs would take only 50mA, and correspondingly less when a smaller number of LEDs are lit.

While such a tool may be considered as something of a luxury, the possession of one is an asset when trouble-shooting a circuit, or even when developing new circuits. Applications of the Logic Clip include:

(a) isolation of individual ICs for detailed examination.

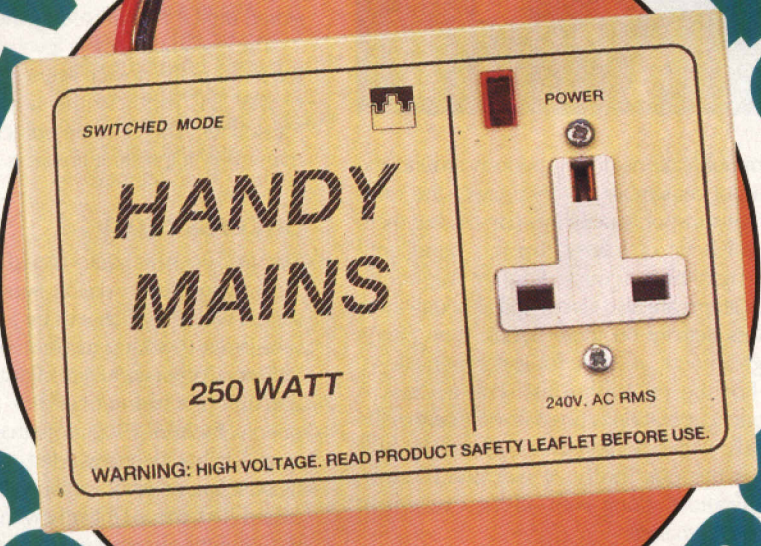
(b) identification of unused or non-functioning gates within a chip.

(c) 'soak' testing of an individual chip, with a continuous display of its functioning on the LEDs.

(d) testing the reaction of the logic circuit to the effects of power supply changes, temperature variations, etc.

Obviously the best feature of the Logic Monitor is its ability to display so many logic levels all at once. It is, therefore, possible to see the simultaneous events at the inputs and outputs of gates, to view the operation of a counter or shift register, both with respect to the presence of the clock signal on the input pins and the logic level changes at the Q outputs. For the latter type of investigation, it is necessary to reduce the clock frequency to a fairly low value, certainly less than 10Hz, in order to be able to follow the events visually.

12V DC TO 240V CONVERTERS



by Alan Williamson and Mike Holmes

This compact power adaptor will convert vehicle battery voltage into UK mains voltage level output for powering small tools and domestic appliances, personal computers, fax machines, printers, etc. on any occasion when the normal 240V mains is not available, but a 12V car battery is! The output power is rated at 200W continuous, with a short term capability of 250W, and a 'surge' capability of 500W. The 240V output is via a conventional, UK style, 13A 3-pin socket with red neon indicator, with which conventional domestic mains plugs can be used.

FEATURES

- **Small size and low weight**
- **Portability**
- **High efficiency switched mode inverter technique**
- **No bulky transformers**
- **Overload and high temperature protected**

APPLICATIONS

- **Run 240V mains appliances from motor vehicle batteries**
- **Power for most DIY tools**
- **Uninterruptible power supplies for VCRs, computers, central heating controllers, etc.**
- **Mains isolators**
- **Run TVs and other domestic equipment when camping, during power cuts, etc.**

Basic Specification of Module

The following specifications are taken at a room temperature of 23°C with the unit started from cold:

Input voltage range:	11 to 15V DC continuous, 16 to 18V DC for 10 seconds
Output voltage:	240V AC (nominal)
Output power:	160W continuous 200W continuous with forced air-cooling, 250W for 7 to 8 minutes, 500W for 10 seconds
Efficiency, approx.:	72%
Output frequency:	48 to 53Hz
Dimensions:	140 x 95 x 45mm
Weight:	<800g

IMPORTANT SAFETY WARNING: The AC output from this unit should be treated with the same respect as the 240V AC mains supply. An electric shock from this unit could prove fatal. Advice given in the manufacturer's Product Safety Leaflet must be followed.

Unit Description

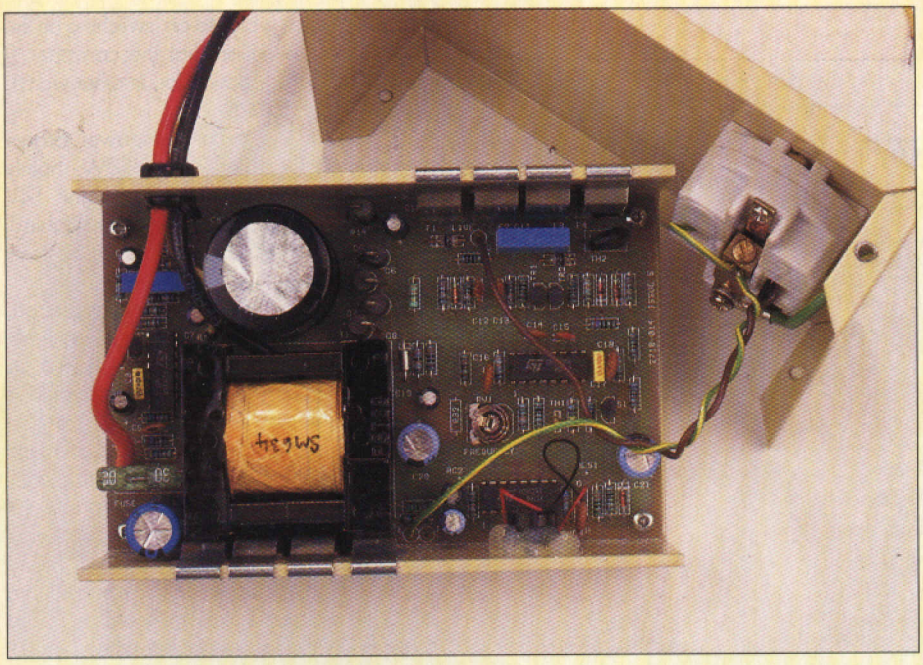
The input supply (battery) connections to the unit are via three unterminated wires. These comprise a heavy-duty Red and Black pair for the actual DC power input, while the light duty Yellow wire is the remote switching control lead. When this yellow lead is connected to the input positive supply potential (+12V), the converter will then be 'enabled' and powered up. This can be confirmed visually by the neon indicator illuminating.

Similarly if the control wire is disconnected then the unit will be switched off, therefore it provides a means of switching the 240V supply on and off without the need to actually switch the heavy-duty low tension supply, with all the problems that that may involve. Figure 1 shows this idea, with the Yellow control wire connected to the auxiliary (position 1) outlet of a motor vehicle's ignition switch, with an optional extra 'inhibit' switch in series. The latter allows the converter to be completely disabled when not required for all normal usage of the vehicle.

Operation

From a 12V input, the quiescent current is 300mA with no load (power consumption up to 6W), so the ability to switch the unit off to conserve power may be desirable. Input current increases by approximately 1A for each 10VA of loading, e.g., a 60W light bulb will draw approximately 6·3A from the 12V low voltage supply.

To generate the 240V AC output, the converter employs switched mode techniques to 'synthesise' a waveform whose essential characteristics will emulate that of the 240V sinusoidal waveform. This output is shown in Figure 2, and as can be seen, the converter attempts to simulate a sinusoidal waveform through using alternate positive and negative pulses, interleaved with periods of zero output. The effective power of this stepped square wave pattern approximates to the same power curve for a sinusoidal waveform. The total time for one cycle is 20ms for a frequency of 50Hz. The actual output voltage can vary from 216 to 255V over a continuous load range up to 1·1A, but the crest voltage will vary within safe limits in proportion to the input voltage level. This stepped output waveform is suitable for most mains powered equipment, even synchronous motors, the exception being fluorescent lighting.



Inside the inverter unit.

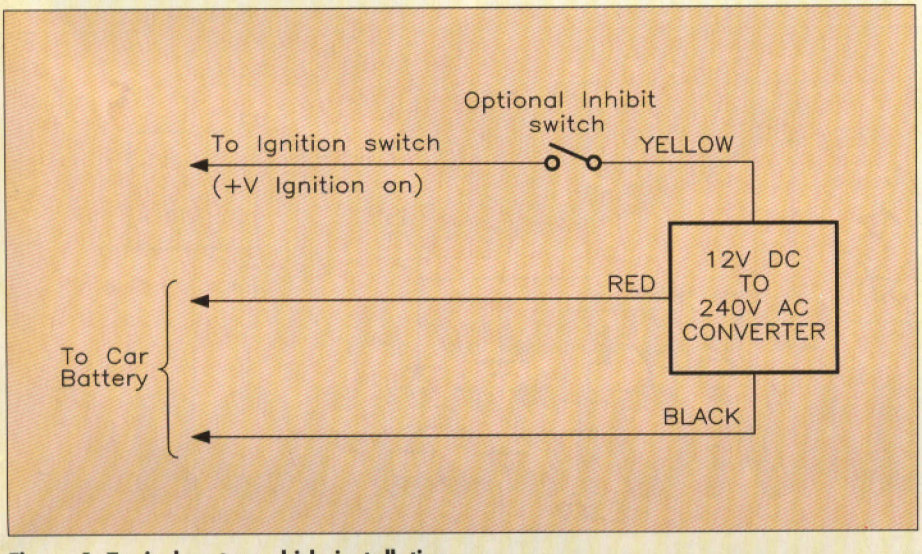


Figure 1. Typical motor vehicle installation.

The converter is fitted with a 'low input voltage' warning bleeper. If the input voltage falls below approximately 10·5V the bleeper will sound continuously, progressively getting louder as the supply voltage falls further. The inverter will then switch itself off if the input voltage is below 10V, and will not start up again until the input voltage has increased and the remote switching lead (Yellow wire) is *disconnected* and then re-connected. This feature is intended to prevent a car battery becoming totally discharged.

Ideally, the vehicle engine should be idling while the converter is outputting high power continuously. Intermittently used power tools will not significantly drain the battery, but anything used continuously could discharge the battery enough to bring on the onset of car starting problems, unless the precaution is taken to keep an eye on the time.

For instance, a small TV set may run for about 6 hours from a fully-charged car battery of, say, 40Ah capacity in good condition, but the battery is unlikely to then be able to start the car. (A portable colour TV would run for rather less time, say 4 hours.) For long periods of use with an appliance of up to 100W it is a good idea to run the engine every half hour or so for fifteen minutes to replenish the battery charge.

Overload Protection

Over-current protection is provided so that if the converter is severely overloaded by unsuitably high-powered equipment over 250W no damage will occur, but only for a *very short time* of a few seconds.

The converter is also fitted with an over-temperature shut-down circuit which operates if the internal temperature rises above 70 to 75°C; the tested sample shut down at 73°C (internal temperature as measured). The converter will only re-start after being allowed to cool, and then the remote switching lead is disconnected and then reconnected.

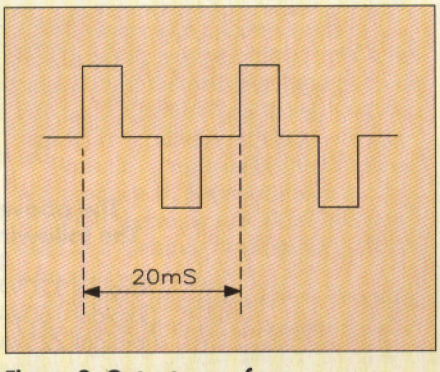


Figure 2. Output waveform.

Using the Converter

Figure 1 shows how the converter is normally wired up to a motor vehicle, as described earlier. If a permanent installation is required, then the free wire ends of the three input leads should be connected, using suitable connectors, as follows: the Red and Black wires to the battery positive and negative terminals respectively, and the Yellow control wire to a convenient point powered by the ignition switch auxiliary (1) position (for example radio supply). The case of the converter is negative earth and can be safely installed in some convenient place *inside* the vehicle (*never* mount it outside!).

Another alternative idea is to exploit the device as an uninterruptible mains power supply. The arrangement in Figure 3 utilises a 13·8V DC mains PSU as the front end of a chain, which includes a car battery and culminates in a converter unit at the output end. As indicated in Figure 3, a 10A power supply, such as XM19V, will be able to provide 100W continuously (93W actual, taking into account a converter efficiency of 73%), whereas a higher-powered 20A version, such as CM50E, will be able to provide nearly 200W. Lower demand will ensure that the reserve is available for charging the intermediate battery; the output of 13·8V (13·5V in the case of CM50E) is the same as the optimum charging voltage in a motor vehicle.

Uninterruptible Power Supply

Although a simple system, this option is somewhat costly to set up. Figure 4 shows how the inverter could be used as part of a more modest UPS (Uninterruptible Power Supply). The converter circuit, as shown, has the disadvantage of voltage drop across the series diodes, but has the advantages of being able to use sealed lead-acid or Ni-Cd batteries, and incorporates a visual indication of mains failure.

Essentially, a toroidal mains transformer with 12V secondaries and a fuse protected primary, provides a DC supply via a bridge rectifier and reservoir capacitor. The total voltage drop across the diodes of the first PW01 device can be 2V or more, making only 14V DC (approximately) available. This is used to supply the converter via one diode of the second bridge rectifier, while at the same time charging battery B1 via a reverse blocking 1N4001 diode and a 3·9Ω resistor. Any tendency to over-voltage is limited by the Zener diode chain, which fixes the maximum at 13·9V. The Red LED indicator is held off by a Darlington switch above being biased off by the DC supply.

If the DC supply (and, therefore, the mains supply) fails, then the converter is left to draw its power source from B1 via the other diode of the second bridge rectifier. With the 14V DC supply no longer available, the Darlington

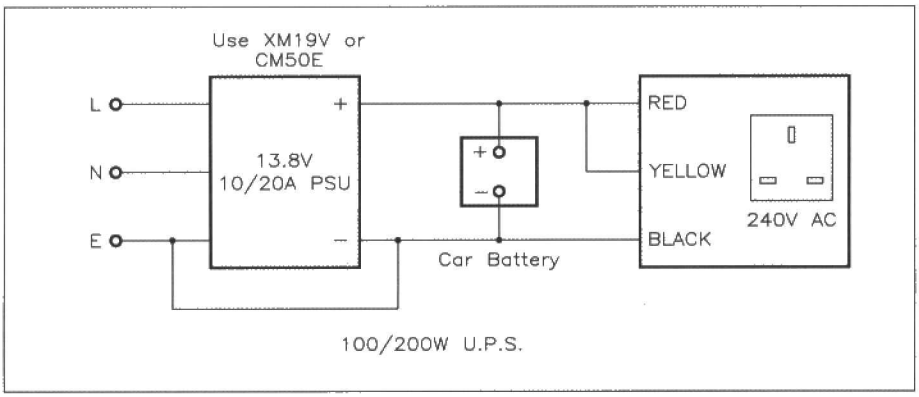


Figure 3. Basic uninterruptible power supply.

Output Power Required	Toroidal Transformer	Fuse F1 Rating, Anti-Surge	Total Secondary Current	Rectifier Type	Forced Air-Cooling Needed
50VA	YK15R	315mA	4A	PW01 (6A)	No
100VA	DH62S	500mA	10A	K01 (25A)	No
150VA	DH68Y	800mA	13·3A	K01 (25A)	Possibly
200VA	DH69A	1A	18·7A	K01 (25A)	Yes

Table 1. Components required for different power options.

transistor switch is biased on, switching on the LED as an indication that the converter is now using battery power (or, in other words, the mains has failed).

However, the maximum power drawn continuously must not exceed 50W, mainly because this is the maximum that the 14V supply can deliver. For higher powers, Table 1 can be used as a guide to choosing the items necessary.

Forced air-cooling, where recommended, is mainly for the *actual* converter unit itself. This provision could be accomplished by building the entire UPS in a suitable case, and mounting the converter unit to the rear of a front panel, with a cut-out for access to the socket and indicator neon lamp, with a cooling fan installed to 'blow over' the unit. All transformers in the above list have duplicated 12V secondaries colour coded as per Figure 4. Either type of bridge rectifier is of a square block encapsulation which should be bolted to a panel for heatsinking, but note type K01 has ¼in. blade terminals and a metal base.

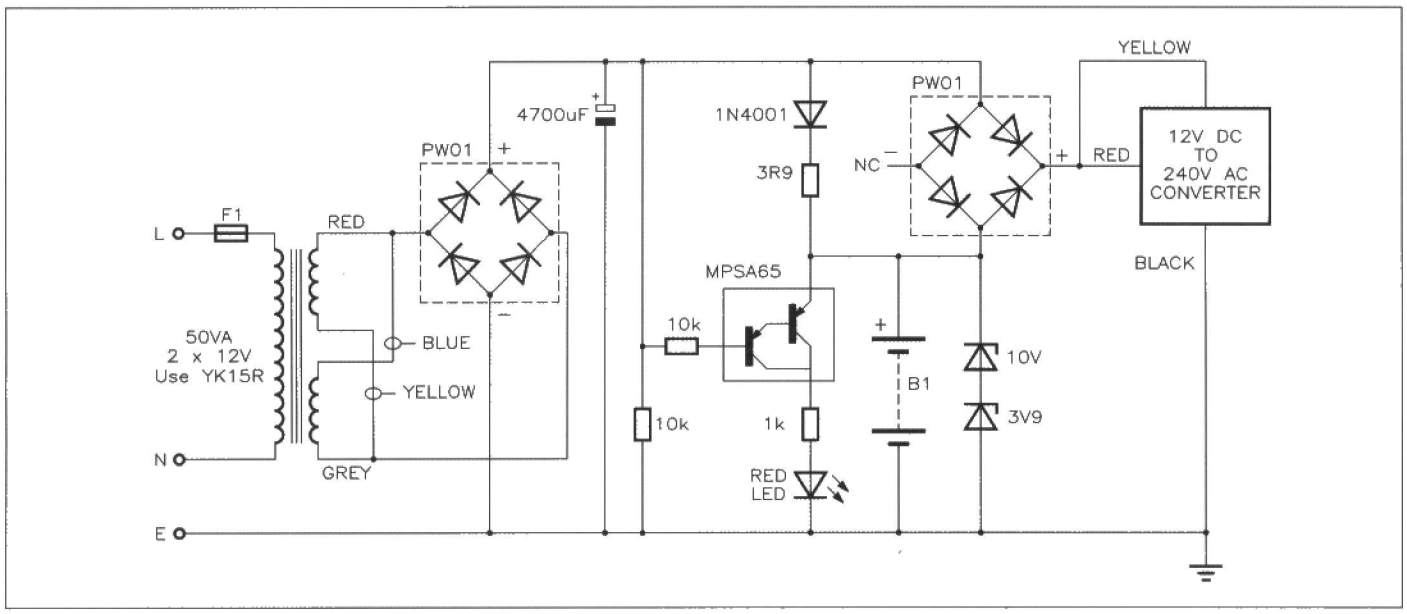


Figure 4. Power supply for customised UPS system.

UN-INTERRUPTIBLE POWER SUPPLY PARTS LIST

RESISTORS

3Ω9 3W Wire Wound	1	(W3R9)
1k Min Res	1	(M1K)
10k Min Res	1	(M10K)

CAPACITORS

4,700µF 50V Can (50VA)	1	(FF27E)
or 22,000µF 35V Can (100VA)	1	(JL59P)
or 22,000µF 35V Can (150-200VA)	2	(JL59P)

SEMICONDUCTORS

Bridge Rectifier PW01 (50VA)	2	(WQ57M)
or K01 (all others)	2	(BH47B)
1N4001	1	(QL73Q)
LED Red	1	(WL27E)
Zener BZX61C10V 1·3W	1	(QF53H)
Zener BZY88C3V9 500mW	1	(QH03D)
MPSA65	1	(QH61R)

MISCELLANEOUS

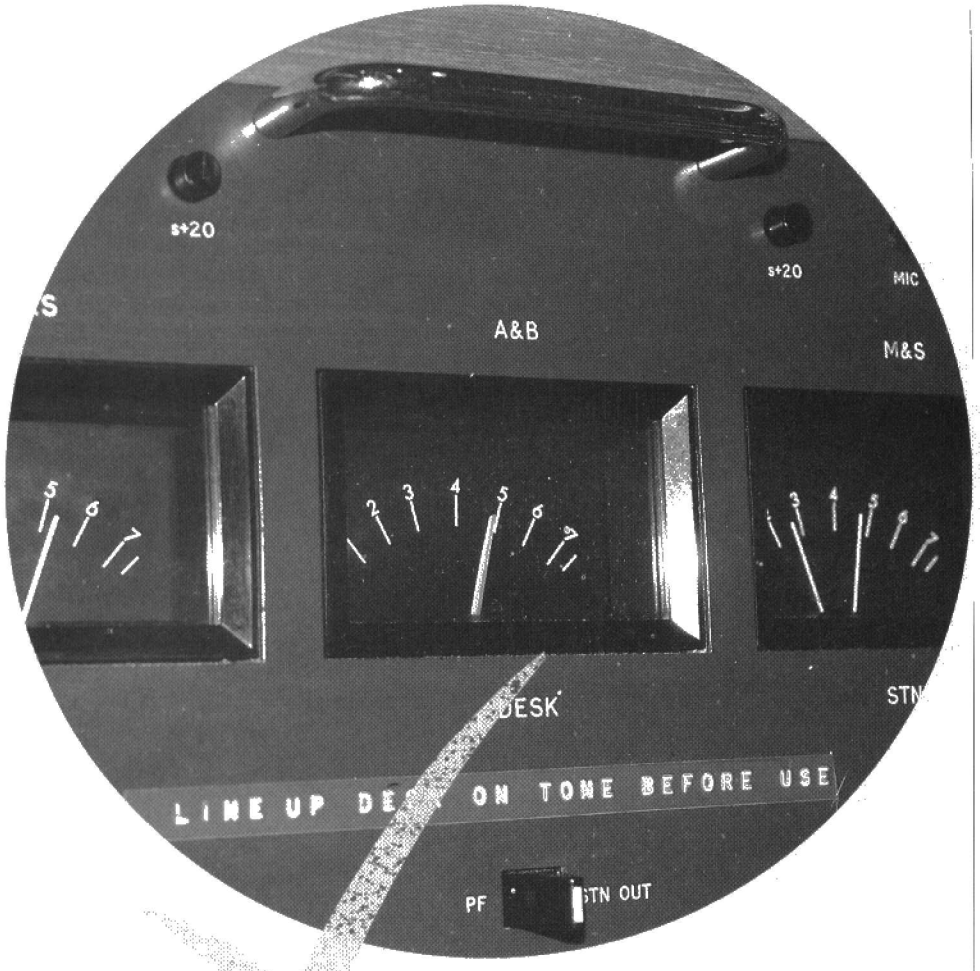
12V DC/240V AC Converter	1	(KR64U)
Toroidal 50VA 12V	1	(YK15R)
or Toroidal 120VA 12V	1	(DH62S)
or Toroidal 160VA 12V	1	(DH68Y)
or Toroidal 225VA 12V	1	(DH69A)
F1 Fuse A/S 315mA	1	(RA07H)
or Fuse A/S 500mA	1	(WR02C)
or Fuse A/S 800mA	1	(RA09K)
or Fuse A/S 1A	1	(WR19V)
Fuseholder, switches, metalwork, matrix board, etc.		As req.

The Maplin 'Get-You-Working' Service is not available for this project.

The above items are not available as a kit.

The following new items are not shown in the 1993 Maplin Catalogue:

(Toroidal 120VA 12V) **Order As DH62S Price £16.96**
(Toroidal 160VA 12V) **Order As DH68Y Price £19.96**
(Toroidal 225VA 12V) **Order As DH69A Price £23.45**



A GUIDE TO PROFESSIONAL AUDIO PART THREE

by T. A. Wilkinson

More on Microphones

The second of our investigations into the world of microphones, looks at the types of transducers used in professional microphones, radio microphones and accessories.

Transducer Types

Dynamic

Dynamic moving-coil microphones are the simplest and most popular of modern microphones. The transducer consists of a thin plastic diaphragm with a coil of fine wire attached to its centre. This coil of wire is surrounded by a permanent magnet. As the diaphragm is excited, and thus moved by the sound waves acting on its surface, a small emf is produced by the coil of wire cutting the lines of magnetic flux.

The size of the resulting voltage will depend not only on the number of turns of wire and the size of the coil, but also on the velocity of the change of air pressure. The output will thus be proportional to the 'loudness', or Sound Pressure Level (SPL), of the sound source. This is easy to prove – as you shout louder into a transducer, it progressively produces more and more output until distortion is produced – at this point, the now (relatively) massive signal is overloading the preamp!

Typically, a moving-coil microphone will produce an output voltage somewhere in the region of 200μV when used at a distance of 30 to 60cm, with a normal speaking voice.

Dynamic microphones are, in general, very robust units. It is for this reason that they are used in preference to other types for stage and PA work. For this sort of work, a dynamic microphone with a cardioid response is most useful as the 'nil' sensitivity from the rear of the unit helps to overcome any susceptibility to acoustic feedback or 'howlround'. They are often dropped or mistreated (although I wouldn't positively encourage this!) by the users – particularly rock vocalists – and would seem to suffer little more than superficial damage to the outer casing.

Ribbon

Ribbon microphones operate along similar lines to moving-coil types, but in this instance the ribbon acts as both diaphragm and a single-turn coil of wire. Thus a voltage is produced as the diaphragm itself cuts the lines of magnetic flux in response to sound waves acting upon it.

Because effectively only a single turn of wire is used as the coil, the emf generated is much smaller than that of the moving coil type described earlier. It is therefore necessary to increase the output level of the transducer, this usually being achieved by including a step-up transformer in the microphone body itself.

The ribbon takes the form of a strip of metal foil, which is often corrugated for increased rigidity. Usually, both sides of the ribbon are exposed directly to the sound source, and thus most ribbon microphones exhibit a figure-of-eight response pattern.

Condenser

Condenser microphones, unlike dynamic types, require some kind of electrical energy source to allow them to function. In basic terms, the transducer consists of two elements – a movable element (known as the 'diaphragm'), and a fixed element (known as a 'back-plate'). The two elements, which are placed in very close proximity and parallel to each other, are made of a metallic or metallised plastic material and are 'polarised' by the application of constant opposing DC voltages.

As the diaphragm moves in relation to the back-plate, the air gap between the two changes, and thus a varying capacitive action is set up. Because the DC charge (Q) is constant, varying the capacitance C (by moving the diaphragm) will produce a varying voltage V (from $Q = CV$).

In certain condenser microphones, a range of polar responses are made possible by using a back-plate with a diaphragm placed on either side of it. If a different level of polarising voltage is applied to each of the diaphragms, it is then possible to change the response pattern.

Because the capacitance of the condenser transducer is very small (somewhere in the region of 20pF) with a very high impedance, it is necessary to provide impedance conversion and amplification close to the transducer without loading the output of the capsule. Ideally, the transducer needs to be presented with an impedance of around 1GΩ in order to operate correctly. FETs have very large input impedances coupled with low noise characteristics,

and so are ideally suited to this task. A FET preamplifier is thus included in the microphone body, in close proximity to the transducer. Figure 1 shows a typical operational circuit for a condenser microphone.

The voltages, which are necessary to allow condenser microphones to operate, are usually provided by means of phantom power arrangements.

Phantom Power

Phantom power is universally used to polarise the elements of a condenser microphone, and to power its FET pre-amplifier. It can also be used to provide an easy means of supplying DC to various microphone accessories. It comes in the form of a DC supply, external to the microphone unit itself, and is either provided by a suitably-equipped mixing desk or stand-alone power unit, or it may form part of a microphone control unit. The stand-alone units are available as mains-operated units, or smaller battery supply units for use in portable applications.

The term 'phantom power' is quite descriptive, as the DC voltage is an 'invisible phantom', at least as far as the AC audio signal is concerned. People usually assume that phantom power is based around a more or less standard figure of 48V DC. Whilst this may be true in many cases, some condenser microphones can operate with a wide variety of polarising voltages, which range from 9V to 52V.

Figure 2 shows one method of applying phantom power to a condenser microphone. The positive side of the DC supply is connected to both signal wires of the balanced line, with the negative side of the supply connected to the screen. Resistors 'R' are included for current limiting purposes, and a commonly encountered value of 6k8 would limit the current to 7mA with a supply of 48V. The value chosen for these resistors should be sufficiently large so as not to shunt the audio signal present on the two signal wires, and should therefore be several times larger than the amplifier input impedance.

DC phantom power is isolated from the AC audio signal by using the inherent DC blocking properties of capacitors or transformers, depending on the design. It should be noted that including any item of equipment in the microphone cable itself may interrupt the phantom power unless specifically designed not to. For example, interrupting the microphone cable with devices (such as microphone splitters or filters) that have transformers or capacitors in the signal path, would prevent the passage of phantom power. Precautions, therefore, must be taken to ensure its continuity.

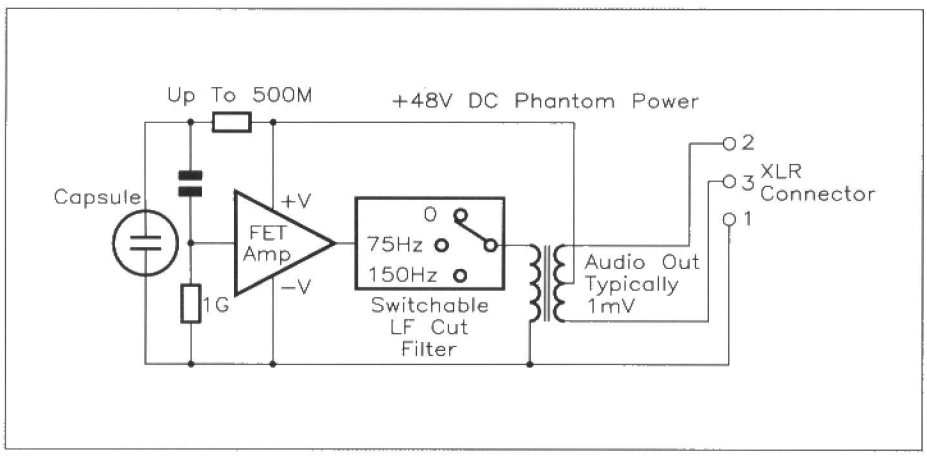


Figure 1. Condenser microphone block diagram.

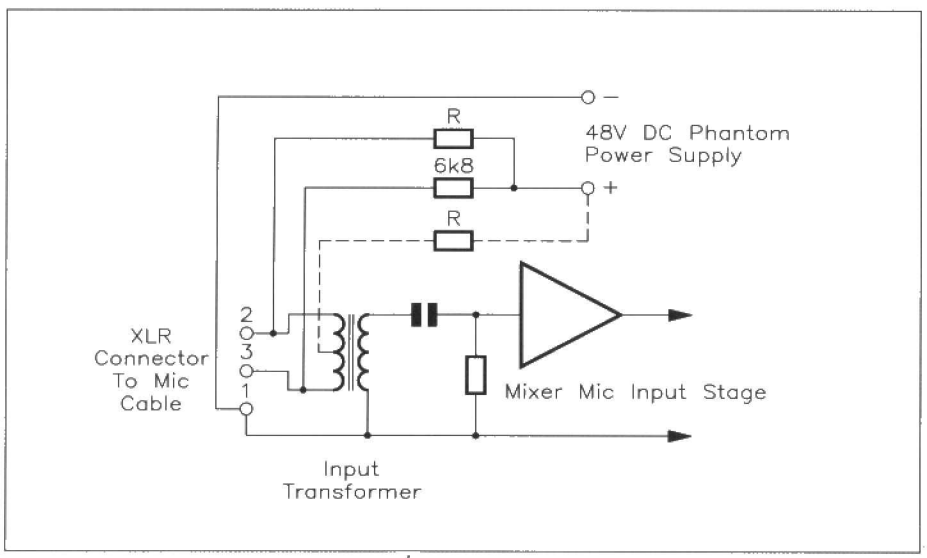


Figure 2. Possible arrangement for supplying phantom power to a microphone via the microphone cable. Alternatively, DC phantom power could be applied to the centre tap of the transformer, as shown by dotted lines.

Radio Microphones

Radio mics are becoming more and more commonplace in many areas of the audio industry. This is, in part, due to the reasonable quality units now becoming more readily available at reasonable cost. The best quality units, however, remain expensive.

Radio mic systems have actually been around for many years, and probably the earliest ones were used in television broadcasting. These were 'Lavalier' (lapel microphones) connected via a short length of cable to a pocket-sized transmitter equipped with a short dangling wire aerial. This arrangement gave the TV presenter total freedom of movement, with the added benefit of an ergonomically acceptable discrete microphone.

This type of system is still used in large numbers today, and similar systems have been developed for use with many types of musical instruments such as electric and acoustic guitars, and various types of brass instruments. These systems are complemented by an extensive range of self-contained hand-held units for use in Radio, TV and stage applications.

All radio microphone systems are governed by the licensing arrangements of specific frequencies and restrictions of maximum power output, and this is ultimately controlled by the DTI.

The use of radio microphones falls into 3 groups, and differing frequencies and approvals apply for each one:

(i) Systems which are available to the general public fall into the 'deregulated' group – these can be used anywhere in the UK, and do not require licensing. There are two sets of frequencies available within this group.

The first set of frequencies has the following five channels for wideband use, with a maximum ERP of 2mW being allowed. 173·800MHz, 174·100MHz, 174·500MHz, 174·800MHz and 175·000MHz.

The second set of frequencies is for narrowband use; here, a maximum ERP of 5mW is permitted. These frequencies are: 174·600MHz, 174·675MHz, 174·770MHz, 174·885MHz and 175·020MHz.

(ii) The second group of devices are those which are intended to be used in fixed locations such as churches, theatres and the like. These devices require a licence to operate, and a specific frequency will be allocated depending on the users geographical location.

(iii) The third group of devices fall into the 'UK general radio microphone' category – again a licence is required. There are 12 frequency allocations available within this group.

There are also a number of specific, tightly-controlled frequencies for use only by UK broadcasting authorities.

Receiver Systems

The quality of any radio mic system, as with any 'wireless' communication set up, will depend just as much (if not more) on the receiver as the transmitter.

Two types of radio mic receiver are available, the single receiver and the 'diversity' (sometimes known as auto-diversity or true diversity) receiver. The single receiver, as the name suggests, is simply one receiver – either tuned to the transmitter's specific frequency, or with a switched selection of two or more frequencies.

The diversity receiver offers two independent 'front-end' (radio receiver) sections, followed by a fast audio switching arrangement, as the block diagram of Figure 3 shows. The switching system will select the front-end with the greatest received signal strength at any given time, and will automatically route this to the main output. Although this may sound a bit 'hit and miss', it works very well in practice – in a good receiver, it is virtually impossible to tell when the switching between RF sections is occurring.

Most manufacturers supply their diversity receivers with the two aerial sockets on the front or rear panel, and may well supply two aerials (generally telescopic or whip) to be attached directly to these sockets, but to get the best overall transmitter coverage it is good practice to use one aerial close to the unit, and another located some distance away and connected via a length of RF feeder. There are, in fact, special dipoles and the like available for this purpose.

The signal-to-noise performance of radio mic systems (particularly the narrowband ones) is often greatly improved by the inclusion of a method of signal processing known as 'companding'. As the name suggests, this involves compressing the dynamic range by a factor of, say, 20dB during transmission, and expanding it again during playback. Many of the better quality units employ a system of this type, and can offer much better results than non-companded systems.

A typical high-quality radio mic system is the SEM 185 from Beyer Dynamic. The microphone has a cardioid response and a built-in transmitter unit with a short trailing-wire aerial. The upper and lower sections of the body separate to reveal a compartment containing a PP3-sized rechargeable battery. The unit will operate for between 2 and 3 hours with a fully-charged battery, but up to 8 hours can be obtained by fitting a non-rechargeable alkaline cell. The receiver is a diversity type, and the system offers companding.

Over the last four years, I have used this unit on literally hundreds of live outside broadcasts, and I am constantly astounded by its quality and range of transmission. It has been used in the most unusual situations, and has penetrated lifts, theatre dressing-rooms, steel-clad buildings, train carriages and even the secure wing of a local prison!

Microphone Cables

A vast variety of cable types are available to complete the vital link between microphone and destination. Somewhere between 'cheap and nasty' and 'esoteric luxury', there is a cable to suit all needs.

The requirements are fairly elementary. The chosen cable should be robust but highly flexible, and flexibility is particularly important in low-temperature situations such as outdoor operations. Cables with lapped rather than braided screens offer greater flexibility, and are less prone to kinking. Another aid to flexibility is the cotton filler material found twisted together with the signal pair in good quality cable, it is said that this also reduces cable microphony.

In addition to physical attributes, the electrical properties of microphone cables need careful consideration. As the output of a professional microphone will generally be balanced, the cable will have two signal conductors (twisted together for common-mode rejection purposes) in addition to the overall screen. Some mic cables actually use four conductors twisted together and connected as a single pair; these are known as 'quad' or 'starquad' cables, and are said to offer very high noise rejection properties – but at a price!

The conductors themselves should be made up of a number of fine strands of good-quality wire in order to maintain flexibility. Resistance of the conductors should be as low as possible – this is particularly important with long cable runs. Something less than 10Ω per 100m would be acceptable. Similarly, core-to-core and core-to-screen capacitance should be small; acceptable figures would be around 140pF/m and 250pF/m respectively.

Overall cable screening is an important area to consider; effective screening is vital if unwanted induced noise is to be kept to a minimum. Poor-quality screening seems hardly worth having, particularly when dealing with small-signal voltages, as it only takes a minute amount of induced noise to turn a good signal into an otherwise unacceptable one.

Lapped, braided, and conductive plastic screening methods are all used in mic cables. Lapped screening is very effective and consists of many strands of wire spirally wrapped around the signal pair; some cables have a double-lapped screen, which is two screens wound in opposite directions. This method of cable screening, due to its effectiveness combined with flexibility, is much more common than other types and is used by all major manufacturers.

Braided screening offers perhaps the ultimate method of keeping out electrical and RF interference but has the disadvantage of being less flexible and more prone to kinking than lapped types. Braided screened cables are thus likely to be found only in situations where very serious induced noise problems are present, or for permanent installations.

Conductive plastic screening is the least common of screening methods presently used, although it is slowly becoming more widespread. Whilst it does offer extreme flexibility, its ability to act as an effective screen is limited.

Many cables are available in a wide range of outer jacket colours to aid identification, but this should be a last consideration when making a choice, and only when the above requirements have been fulfilled should any priority be given to colour.

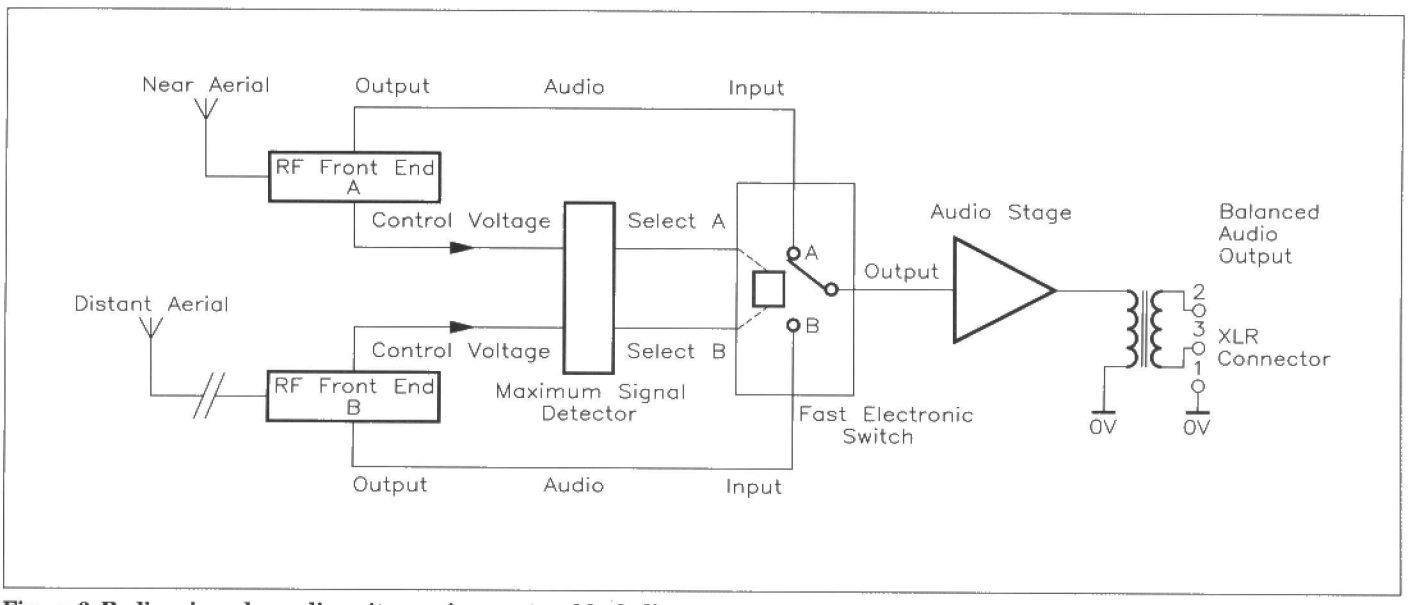
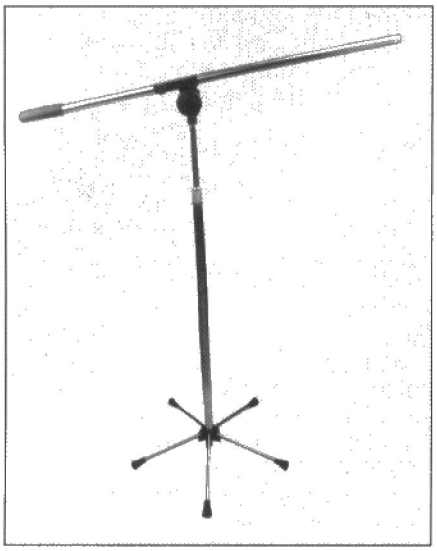


Figure 3. Radio microphone diversity receiver system block diagram.



The importance of a good microphone stand cannot be overstressed!

Microphone Accessories

The subject of microphone accessories is vast and would fill an entire feature itself, although I doubt that would make very interesting reading!

The most basic accessories are stands and mounting devices. A microphone could be mounted on any stand, but some do the job rather better than others – and, of course, there are stands for every conceivable purpose – table stands, floor stands and even one called a Cathedral Stand! All have their uses, but if I was to buy one general-purpose 'all rounder', I would choose a floor stand with a boom arm attached. In terms of flexibility, they cannot really be beaten, and for sheer practicality most of these types fold up to quite small dimensions.

Again, some are better than others – and the better types tend to have a good degree of immunity from mechanical floor noise transmitted through the legs. This is achieved by a combination of sprung metal components in the legs with substantial rubber feet – much of the floor noise is diminished by the time it reaches the stand tube itself.

Stand adjustments are made possible by interlocking tubes and rotating sections and, once set, all movable components are clamped together with collars and thumb screws. It is, therefore, essential to tighten fully those securing devices in order to eliminate stand rattle, which may otherwise spoil a perfectly acceptable recording.

Other everyday accessories available include matching transformers, and a wide range of windshields designed to reduce wind and pop noise. It is particularly important to use these outdoors, or when working close to a mic. The most common is the foam type, which is inexpensive and does the job quite well. There are very specialised windshields for use with 'gun' mics, which resemble Dougal of Magic Roundabout fame (i.e., covered in 'shaggy hair'), and are quite common sights at news conferences, and in hot pursuit of cabinet ministers and celebrities!

Recording studios use a rather an odd-looking device for reducing wind and pop noise – it consists of a circular plastic, metal or wooden frame with a fabric mesh material (similar to a piece of ladies stocking, although which piece I am not sure!) stretched across it. The device is not attached to the microphone itself, but is placed in front of it and clamped to the microphone stand. It is said to possess a transparent characteristic, without causing any significant HF loss.

Splitters and Combiners

Microphone splitters and combiners are really self-explanatory in terms of what they do, and so detail here is kept to a minimum.

A microphone splitter would be used to split a single microphone, and feed it to more than one destination. A typical example would be a live band stage-show that must be fed to a PA system, whilst simultaneously feeding a second destination such as a recording or broadcasting set up. If a feed was not available from the PA mixer's outputs, or was thought to be unsuitable, then it is likely that the microphone signals would be split and routed to both the PA mixer, and the recording/broadcasting mixer independently. This allows each mixing engineer to control his (her?) own balance of sounds, being independent and electrically isolated from each other. Electrical isolation may be particularly important for safety reasons, and may well avoid serious earth loop problems.

Microphone splitters generally tend to be passive devices, and so do not require any sort of DC supply. Transformers are used to split the input into two or more outputs; this device will be a high-quality purpose-built unit with a single primary winding and two or more secondary windings (depending on the required number of outputs).

Phantom power must be considered when using microphone splitters, as a transformer will not pass phantom power unless the unit is specifically wired to do this. Some manufacturers pre-wire their units to pass phantom power, whilst others do not. This leaves the user to organise the wiring to his own liking. Whatever the case, it is a 'must' to check the unit's specifications in order to be certain of particular arrangements.

Combiners

A microphone combiner is really a reversal of the above – it is used to combine the input signals from two (or more) microphones to provide a single output. Again, this is usually a simple passive device based around transformers, but this time with multiple primaries and a single secondary winding. Due to the fact that no provision is made for controlling the levels of the individual microphones, its uses are limited – it could be considered as a very simple mixer.

Applications include self-operated sports commentary situations where two commentators 'hand over' to each other. In this situation, where resources and technical assistance may be limited, the lack of control over each microphone may well be quite acceptable.

Some splitters and combiners provide 'phase reverse' and 'earth lift' switches. The former reverses the phase of the 'hot' (phase) and 'cold' (return) signal wires, while the latter removes all (or part) of the earth path through the unit. While these facilities are not always necessary, they may occasionally overcome compatibility and earth loop problems.

A very useful accessory, which no (condenser) microphone user should be without, is a phantom power tester. This is a simple device which can be plugged into a mic cable in place of a microphone, and is used to detect the presence of the DC phantom supply, giving an instant indication of a faulty (open or short circuit) cable as an added bonus.

Two LEDs are arranged to give a visual indication of the phantom power status on both the 'hot' and 'cold' legs of the balanced line, as in Figure 4. The red LED has its anode connected to the 'hot' leg and the green to the 'cold' leg. Both cathodes, via current limiting resistors R1 and R2, are commoned together and connected to the screen of the cable.

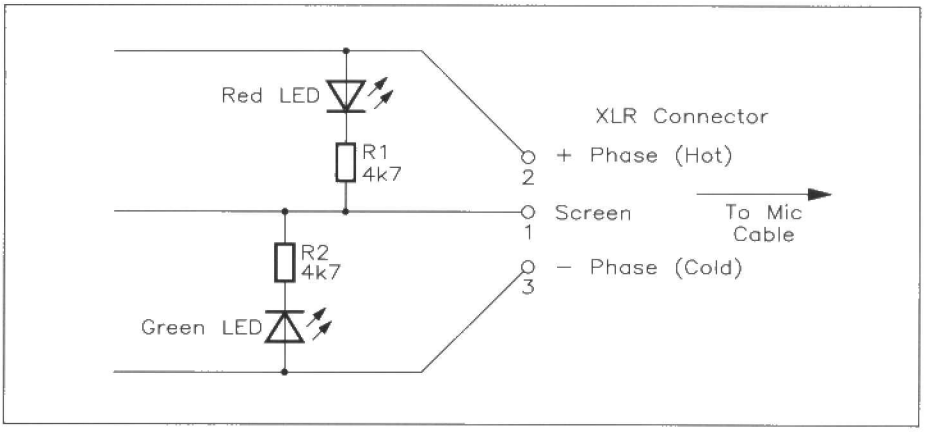


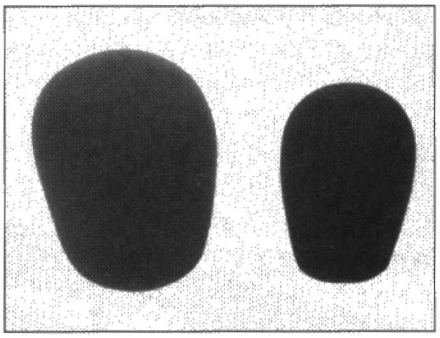
Figure 4. Phantom power tester. Attaching this device to the microphone cable will give an instant indication of phantom power status (if any), and thus the condition of the cable itself.

If both red and green LEDs illuminate, this indicates phantom power present on both legs and a complete and working mic cable. Should neither LED light, then the phantom supply has failed completely (or it is shorted to the screen), both conductors are open circuit (generally unlikely) or the screen of the cable is open circuit. If only the red LED illuminates, then the 'cold' leg signal wire is open circuit – similarly, if only the green LED is alight, then the 'hot' leg will be open circuit.

Commercial testers of this type are not particularly expensive, and many are housed or built into the body of a male 3 pin XLR connector for convenience and compactness. It's a very handy tool to keep close to your mics and cables, and it would not be beyond even the most inexperienced engineer to build one in half an hour or so.

Finally, choosing a microphone is not easy, but with a little careful thought and consideration of what you actually need and how much you can afford, it should not be too stressful!

With any microphone type there are many to choose from, and if budget is not a problem then you will be spoilt for choice. If your area of use is mainly for interviews and outdoor situations then, on the basis of common sense, go for a dynamic omnidirectional microphone. This offers the sturdiness and simplicity (no DC required) of the dynamic transducer, and the flexibility of an omni response, which has general pick-up characteristics ideal for interview



Windshields help to reduce wind and 'pop' noises.

situations, and when used outdoors will not suffer too badly from the elements. In addition to the range offered by Maplin, two professional units that come to mind are the AKG D130 and the Beyer M58 NC – which has an extra-long handle for getting really close to your victim!

Should the bulk of your microphone work involve a 'single-point' sound source (such as one person speaking) or perhaps indoor use, particularly in 'echoey' rooms, then it makes sense to select a cardioid unit. Its directional properties make it more selective than an omni and will reject unwanted reflected noise. Again, a dynamic type is probably best in this sort of situation.

For studio-based work where the acoustics, and the conditions under which a microphone will be used, are more tightly controlled, then the quality of condenser and ribbon units can be exploited. Again, there are many from which to choose, but a bad mistake in selecting a quality condenser would be very costly. If buying a general-purpose condenser mic with no particular application, a multipattern type such as the excellent AKG C414 is probably the wisest choice. This allows great flexibility without being tied to any one polar response.

Where a microphone is being selected for use with a specific type (or group) of instruments, or solely for vocal work, then it would be advisable to seek advice from a specialist professional audio dealer – after all, certain types of microphone are designed with particular applications in mind, and may thus be more suitable than others.

An important area to consider with any microphone (but particularly hand-held units) is its susceptability to handling noise. Better units will have their capsule mounted using an elastic suspension arrangement which improves things greatly. If you are not sure, then check out this area of a microphone's performance before you buy.

In any event, try to get some unbiased opinions from other users and try-out a unit yourself, where possible, before you lay out your cash!

Next Month

Part Four of this series looks at methods of amplifying microphone signals, and techniques for getting the best out of microphones.

CLASSIFIED

Placing an advertisement in this section of 'Electronics' is your chance to tell the readers of Britain's Best Selling Electronics Magazine what you want to buy or sell, or tell them about your club's activities – Absolutely Free of Charge! We will publish as many advertisements as we have space for. To give a fair share of the limited space, we will print 30 words free, and thereafter the charge is 10p per word.

Placing an advertisement is easy! Simply write your advertisement clearly, in capital letters, on a post-card or sealed-down envelope. Then send it, with any necessary payment to: Classifieds 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex SS6 8LR. Advertisements will be published as soon as possible, space allowing. No responsibility is accepted for delayed publication or non-inclusion of advertisements.

Private individuals only are permitted to advertise in this section; commercial or trade advertising of any kind is strictly prohibited by law. Advertisements are only accepted by the Publisher on this proviso. Readers who have reasonable grounds to believe that they have been misled as to the nature of an advertisement are advised to contact the Publisher and their local Trading Standards Office.

VARIOUS

2kW PETROL GENERATOR to dispose of, will swap for a dual trace oscilloscope and function generator, or the following to run on my ST1040: mouse, colour monitor and printer. Tel: (0795) 874647.

GIANT CLEAROUT! Long list of unused components including ICs, capacitors, resistors, some in large quantities. All at bargain prices. Send S.A.E. for list to: M. J. Dean, Blenheim, Walton Lane, Bosham, Chichester, West Sussex, PO18 8QF.

GOULD 20MHz DIGITAL STORAGE OSCILLOSCOPE £450 o.n.o. Also Alcatel VT258 video terminal, like a fax machine; computer keyboard, modem, ASCII. £150 o.n.o. Tel: (0792) 579009 (Swansea).

MAPLIN DIGITAL CAR TACHO, built and tested, £17.50. Maplin 'Mapmix' 6 Channel Audio Mixer, built and tested, £20. Hi-Fi or PA amplifiers built to your own specification. For details Tel: (02357) 67550.

TELEQUIPMENT S31 OSCILLOSCOPE (valves!) with manual, works fine and includes double-trace generator, £50 o.n.o. for the two or will split. Also green screen monitor similar to that shown in Maplin Catalogue (page 180), £40 o.n.o. Tel: (081) 505 8913.

SCRAP PCBs, mainly from disk drives, £3 per kilo. Stepper motors from £2, fans £4, EPROMs and ICs. Send S.A.E. for list to: Colin Stirling, Cottar Acre, Knowehead, Star of Markinch, Glenrothes, Fife, KY7 6LA.

RACAL REDAC COLOUR PCB DESIGN STATION hard disk, printer, desk, twin tape drives, 70 cartridges and full documentation and software, £250. Tel: (0443) 207037 (South Wales).

ADVANCE 3001 40MHz DUAL TRACE OSCILLOSCOPE with service manual. Fully operational, £195. Tel: (0443) 207037 (South Wales).

CANON A1 CAMERA £140, 50mm lens £25, 28mm lens £45, Hanimex 70-140 zoom £50, Canon flashgun £20, Cygnet case £15, 9 assorted filters £10, or £300 for the lot. Tel: (0268) 767984.

COMPUTERS

TEKTRONIX 8002A MICROCOMPUTER development system complete with terminal, 8048 and 8085 emulators. Software and manuals including TekDOS, PASCAL and assemblers, £100. Tel: (0443) 207037.

HP9816 COMPUTER with hard disk, 3½in. floppy drive, monitor and IEEE interface. Complete with HP BASIC and manuals, etc. Not IBM compatible! Very good condition, only £195. Tel: (061) 485 7367 (Manchester).

MICROPROFESSOR MPF-1P Z80 trainer including built-in editor and assembler, memory, I/O and applications card, cost over £400, yours for £100. Also have modem V21/23 auto-answer/dial. Fully Hayes compatible! Offers? Tel: Mel, (0533) 419742.

CIRCUIT DESIGNER an electronics CAD program for the monochrome Atari ST. Complete with laser printed manual. Send £7 to: Darren. P. Goodwin, 4 Coniston Drive, Bolton on Dearne, Rotherham, South Yorkshire, S63 8NE.

OLIVETTI PC1 XT with colour CGA monitor, twin 3½in. floppy disk drives, mouse. IBM compatible, with manuals, some software. In original packaging. Only £300 or v.n.o. Tel: (0299) 402592.

MODEM TRANSAM M1 great for Maplin CASHTEL, £20. Also book 'Inside OS/2 2.0', as new, £25. Contact: I. Smith, 3 Park View, Balmullo, Fife, KY16 0DN, or tel: (0334) 870221 (evenings/weekends only).

PANASONIC PRINTER KX-P1180, v.g.c., complete with manual and two spare ribbons, £55. Tel: (0366) 728917.

TO ALL 6502 PROGRAMMERS. Write fast, efficient and compact M/C programs easily using my Assembly Generating Compiler. Its own expandable language implements loop structures, conditional tests, string handling, I/O, integer maths, etc. in 65XX machine code. Original package runs on C64; IBM PC version also available to help program 6502 microcontroller cards, etc. or other machines. Compiler and assembler source listings can be made available if required. Expandable routine library. C64 disk has lots of demos, PC disk has lots of extra utilities. Send largish, e.g., C5 S.A.E. for more details to: Level 3, Aurora, Church Road, Laindon, Basildon, Essex, SS15 5SL.

ELECTRONIC MAGAZINE INDEX for 'Electronics – The Maplin Magazine' and 'Everyday with Practical Electronics' runs on any Acorn Archimedes equipped with RISC OS 2 or 3 plus the application 'ArcScan 3'. Send £5, including postage and packing, to: M. Kay, 69 Cobnar Road, Woodseats, Sheffield, S8 8QD.

WANTED

OPERATING SYSTEM AND SOFTWARE for 8086 based B/T Merlin M4002 system with 5¼in. disks. Will swap for AR88D receiver and manuals. Tel: (0706) 622400 (Manchester).

VALVE FM TUNER any condition. Tel: (0702) 202556.

SERVICE INFORMATION for Sony C7 Betamax VCR. Tel or Fax: (0752) 336703.

HEATHKIT MICROPROCESSOR TRAINER ET-3400A required, any age or condition, working or not. Tel: (0787) 223511 (Essex), evenings.

RADIO SCANNER to suit satellite reception at 137MHz. Good sensitivity required. Will pay up to £150. Also interested in other satellite equipment. Tel: Ian, (0232) 868614 (Belfast).

PLESSEY REMOTE CONTROL IC type ML927. Please advise price, all postage refunded. Contact: Frank Cosgrove, 59 Fenton Road, Bournemouth, Dorset, BH6 5BS.

PLOTTER flatbed and HPGL compatible! IDE drive, UV exposure box, faulty gear for stripping! Test gear, buy or photograph gear to swap, W.H.Y., etc. Tel: Mel, (0533) 419742.

DBX NOISE REDUCTION system for 'normal' tapes. Compression ratios; encode 2:1, decode 1:2. Will pay £25 for faulty item or £50 working plus delivery. Tel: Drew, (0270) 764624 (Sandbach) after 6.00pm.

CLUB CORNER

ELECTRONIC ORGAN CONSTRUCTORS SOCIETY. For details of meetings Tel: (081) 902 3390 or write 87 Oakington Manor Drive, Wembley, Middlesex, HA9 6LX.

WIRRAL AND DISTRICT AMATEUR RADIO CLUB meets at the Irby Cricket Club, Irby, Wirral. Organises visits, D.F. Hunts, demonstrations and Junk Sales. For further details, contact Paul Robinson (G0JZP) or Tel: (051) 648 5892.

TESUG (The European Satellite User Group) for all satellite TV enthusiasts! Totally independent, TESUG provides the most up-to-date news available (through its monthly 'Footprint' newsletter, and a teletext service on the pan-European 'Super Channel'). It also provides a wide variety of help and information for its members. For further information, contact: Eric W. Wiltsher, **TESUG,** Rio House, Stafford Close, Ashford, Kent, TN23 2TT, England.

THE BRITISH AMATEUR ELECTRONICS CLUB (founded in 1966), for all interested in electronics. Four newsletters a year, help for members and more! UK subscription £8 a year (Junior members £4, overseas members (£13.50). For further details send S.A.E. to: The Secretary, Mr J. S. Hind, 7 Carlyle Road, West Bridgford, Nottingham, NG2 7NS.

MODEL RAILWAY ENTHUSIASTS? How about joining 'MERG', the Model Electronic Railway Group. For more details contact: Mr Eric Turner, Treasurer MERG, 38 North Drive, Orpington, Kent, BR6 9PQ.

Text by Martin Pipe

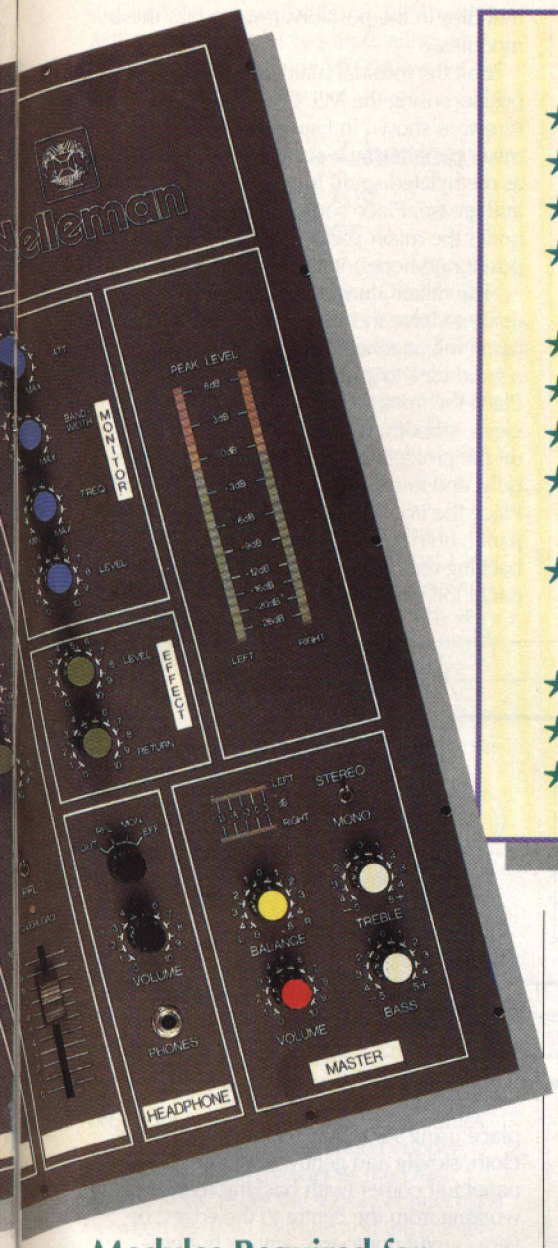
Over the last few issues of 'Electronics', details of various modules that, although useful in their own right, can be put together to form a comprehensive stereo mixer. The modules in question are: the Precision VU Meter (Issue 59, November 1992); Dual Tone Control (Issue 60, December 1992); Dual Stereo Fader (Issue 61, January 1993); Monitor and Effects Module (Issue 62, February 1993); Dual Input Module (Issue 63, March 1993); Master and Headphone Module (Issue 64, April 1993); and the Mixer PSU (Issue 65, May 1993). This article explains how these modules can be combined into a 6 or 12-Channel Mixer.

BRINGING IT ALL TOGETHER

MODULAR MIXING SYSTEM

PART EIGHT

The completed 6 & 12 channel mixers



FEATURES

- ★ High Quality
- ★ Modular Design for Serviceability
- ★ Wide Variety of Input Options
- ★ Up to 6 or 12 Stereo Channels Available (depending on version)
- ★ DC-Controlled Electronic Faders for Reliability
- ★ LED VU Input Level Meters for each Input
- ★ Low Noise and Distortion
- ★ Comprehensive Equalisation and Monitoring Facilities
- ★ Effects Loop (12-Channel version only)

APPLICATIONS

- ★ Radio Stations
- ★ Discos
- ★ Semi-Professional and Domestic Recording Studios

Modules Required for 6-Channel Mixer

The 6-Channel Mixer is made up of the following modules: 3 Dual Stereo Faders; 3 Dual Input Modules; 1 Monitor and Effects Module; 1 Mixer PSU and toroidal transformer; and 3 Dual Stereo VU Meters (which will be discussed later in this article). A pre-drilled and punched aluminium control panel is available for the 6-Channel Mixer, in addition to an attractive self-adhesive front-panel legend.

Modules Required for 12-Channel Mixer

Two modules are specific to the 12-Channel Mixer – these are the Precision VU Meter (1 required) and the Dual Tone Control (6 required). The other modules are required in the following quantities: Dual Stereo Fader (6); Dual Input Module (6); Monitor and Effects Module (1); Mixer PSU/ Transformer (1); Dual Stereo VU Meter (6). As for the 6-Channel Mixer, a pre-prepared control panel and legend are available to give your mixer that professional look.

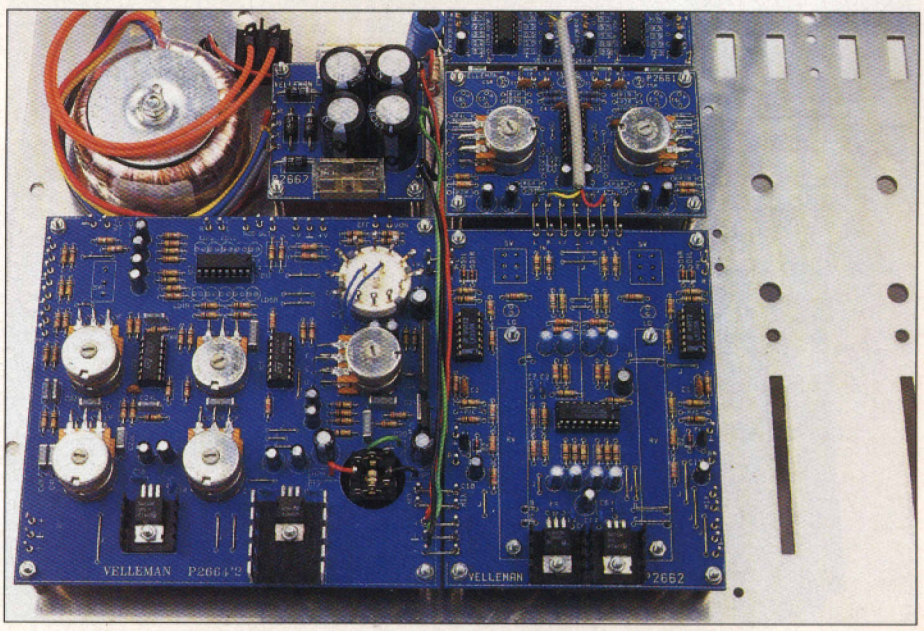
Dual Stereo VU Meter

This simple module, as used in both mixers, allows the input level of each channel to be monitored. As can be seen from the circuit diagram, Figure 1, it consists of four identical 5-LED bargraph driver circuits, each based around half a U2066B IC. The components associated with the two ICs determine the attack and delay times, and the bandwidth over which indication will take place. Each of the four bargraph displays is made from three green, one orange and one red LED; the LEDs operate at approximately the following levels: red +3dB, orange 0dB, and green at −3, −8 and −13dB.

Dual Stereo VU Meter Construction

Construction of the Dual Stereo VU Meter is fairly straightforward. Note that the resistors should be mounted vertically, and that the two ICs are located in sockets. When mounting the capacitors, ICs and LEDs, be sure to observe correct polarity. Talking of which, the LEDs are fitted from the track side of the board so that their tips are 23mm above the base of the PCB. The shorter (cathode) lead of each LED is aligned with the flat side of the LED shown on the board legend; note that LD5L/R are the red LEDs, LD4L/R are the orange and LD1 to 3L/R are the green. Solder only one lead from each LED; the second leg should not be soldered until all LEDs have been positioned at the correct height and are squarely aligned.

After completing assembly, it is prudent to check your work – finding any incorrectly- placed components could save considerable time and expense later on. Other gremlins to watch out for include solder bridges/whiskers and poor joints.



Close-up view of partially-assembled 6-Channel Mixer, showing Module interconnections.

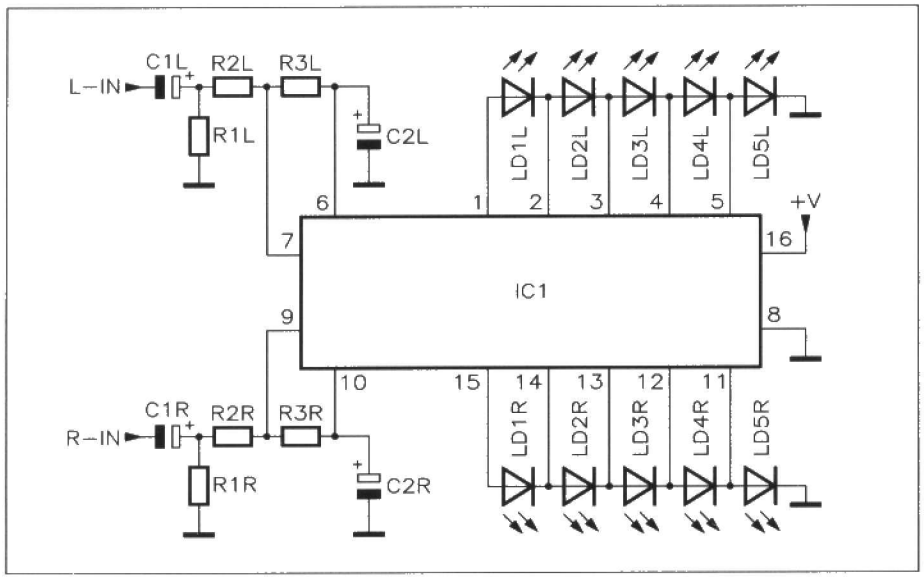


Figure 1. Dual Stereo VU Meter circuit diagram.

Building the 6-Channel Mixer

Before you can build a 6-Channel Mixer, you must ensure that all of the required modules (these were outlined earlier) are built up and tested wherever practically possible.

Begin construction of the mixer panel by enlarging the hole for the neon rocker switch, as shown in Figure 2. For all of the PCB positions except the VU meter modules, fit the M3 countersunk screws through the mixer panel from the front. Next, slide the 1/4in. spacers over the screws, followed by the M3 threaded spacers. Fit the mounting hardware supplied with the VU meter modules in the positions reserved for these modules.

Bolt the toroidal mains transformer into position using the M5 x 40mm countersunk screw, as shown in Figure 3. Clean the mixer panel using a suitable solvent (such as methylated spirit) to remove any dust and grease. Place some wooden blocks under the mixer panel so that it can be positioned horizontally facing upwards.

The mixer aluminium front panel is now ready to have the plastic self-adhesive front panel foil attached. At this stage, it may be a good idea to get someone to help you. Place the front panel foil, face-down, on a clean, smooth, flat surface, and then peel off the protective backing from one corner only, and fold it back as shown in Figure 4. Place the front panel foil onto the mixer panel, holding up the corner with the backing removed. Carefully align the front panel foil over the mixer panel, and hold in

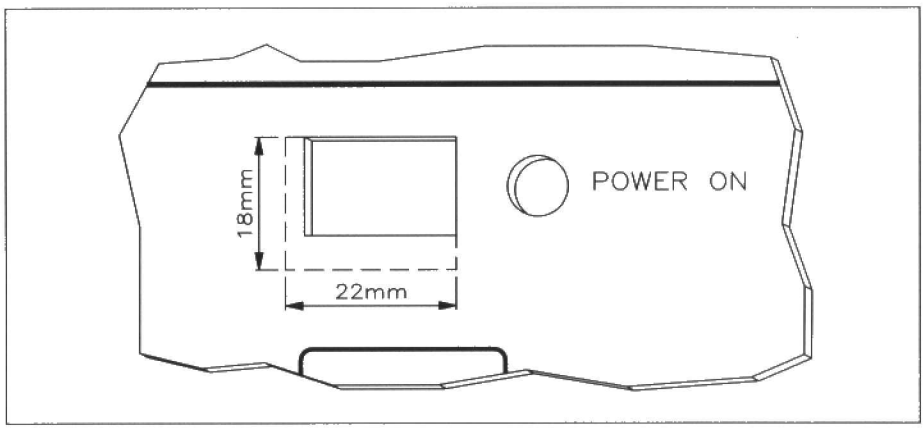
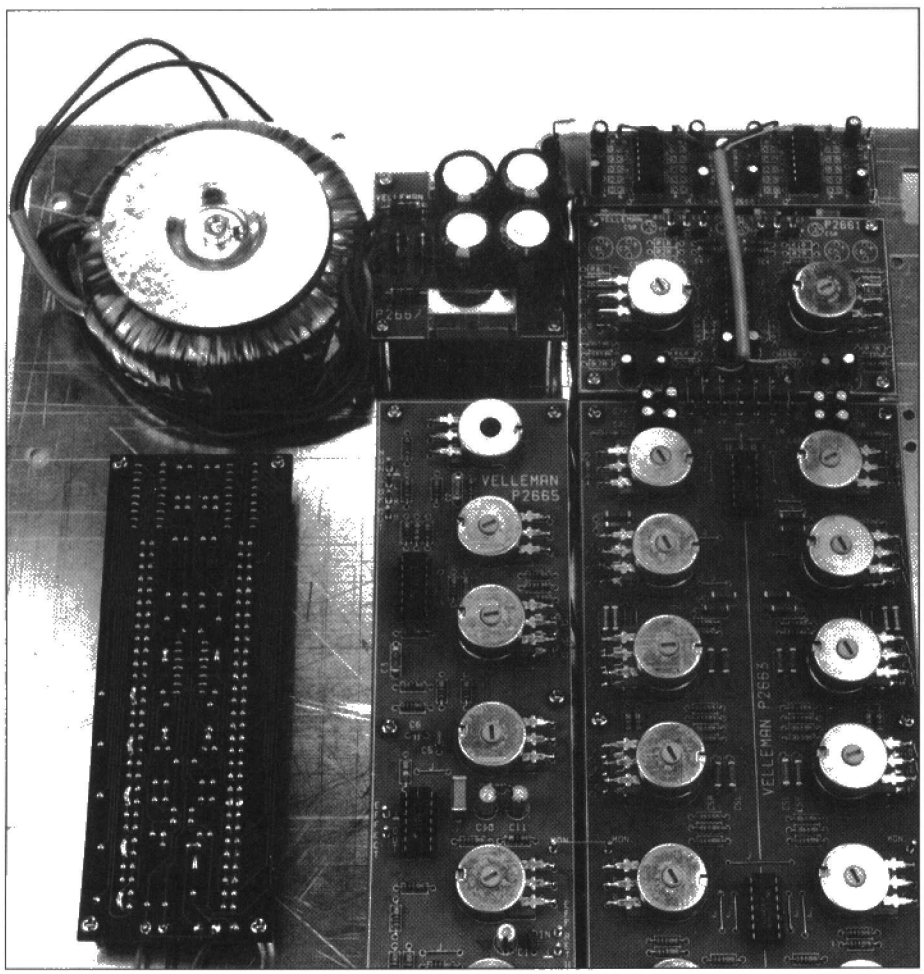


Figure 2. Enlarging the front panel hole for the power switch (6-Channel Mixer only).



Close-up view of partially-assembled 12-Channel Mixer, showing Module interconnections.

place using some sticky tape. Using a soft cloth, slowly and gently rub down the front panel foil corner (with backing removed), working from the centre to the edges; be very careful not to trap any air bubbles under the foil. Once the corner has been firmly attached, the sticky tape can be removed. The rest of the front panel foil can then be attached by slowly drawing out the protective backing, while being rubbed down. Once the foil has been rubbed down to your satisfaction, it should be trimmed around the now enlarged mains switch mounting hole (refer to Figure 2 again).

Temporarily fit the Dual Input and Master and Headphone Modules – mark off the potentiometer and switch spindles 8mm above the mixer front panel, remove the modules and trim the shafts; the Dual VU Meter, Dual Input and Dual Fader Modules can now permanently be installed. Attach short lengths of wire to the Master and Headphone Module for the headphone socket connections, as shown in the manual supplied with the module; once these wires have been soldered in place, it can be installed.

Fit the knobs to the potentiometer and switch spindles; fit the red caps to the gain and master volume knobs, the blue caps o the headphone volume and master/PFL knobs, the white caps to the bass and treble knobs, and the yellow caps to the balance knob. The slider knobs require modification; enlarge the slot to 2 x 11mm to enable them to be fitted over the slider spindles. Alternatively, the correct-fitting 'official'

slider knobs are available in a set, together with the other knobs required, although this option (Order Code VX00A) works out somewhat more expensive.

The Birth of a 6-Channel Mixer – Wiring the Modules Together

Make the PFL L/R, MIX L/R and +V/0/–V connections between the first Dual Fader Module and the Master and Headphone Module using tinned copper wire. Due to the way the modules have been designed to fit together, all these links have been brought to the side of each board. This makes for easier assembly; as only short links are involved, no screened cable is required. The PFL L/R, MIX L/R and +V/0/–V connections should be made, in a similar way, between the first Dual Fader Module and the other two in the system. Note that 0V, or ground, connections are identified on all the modules by an 'upside down T' symbol. Next, links should be made between the IN L/R and +V/0/–V pins, located at the top of the Dual Fader Module, and the corresponding pins of the Dual Input Module.

Using 4-core overall screened cable, connect the two sets of L/R IN pins of each Dual Stereo VU Meter Module to the relevant L/R OUT pins of the nearest Dual Input Module. The screen of the cable is connected to the 0V pin of the input module only.

Power supply arrangements must now be made for the Dual Stereo VU Meter Modules. Fit a 1000µF 35V electrolytic capacitor and 39Ω 7W resistor, and make the 0V connection, as shown in Figure 5. The supply pins of all VU meter modules should be bridged using tinned copper wire, in the same manner as the Dual Faders. Next, make the supply connections between the PSU Module and the Master and Headphone Module using the 16/0·2 red (+V), green (0V) and black (–V) wire.

Trim the leads of the 'power on' LED to 5mm from the package body, and solder 200mm lengths of red and black 16/0·2 wire to the device. The black wire is connected to the cathode, which can be identified as the flat side of the package. Insert the LED bezel into the panel next to the neon rocker switch position, then insert the LED into the bezel. Solder a 47k 0·6W resistor to the +V pin of the PSU Module; the red wire from the LED should be connected to the free end of the 47k resistor. The black wire from the LED should be soldered to the –V pin of the PSU Module.

Power Supply Arrangements

The mains transformer can now be connected to the PSU Module; the red wire should be soldered to the 'A' terminal, the yellow wire to the 'B' terminal, blue to 'C' and grey to 'D'.

Check, using a multimeter set to its highest resistance range, that there is no connection between the aluminium front panel and the power supply rails (i.e. +V/0/–V). Fit the headphone socket (note that only the HF93B or BW80B jack sockets will fit the front panel); the wires

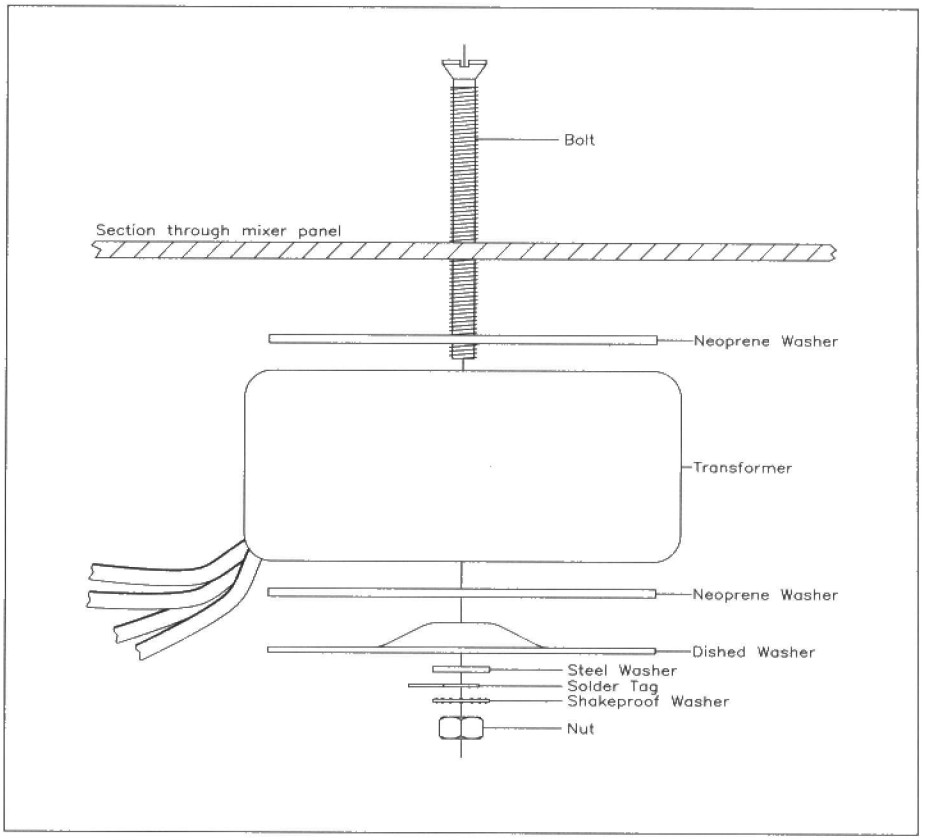


Figure 3. Bolting the mains transformer into position.

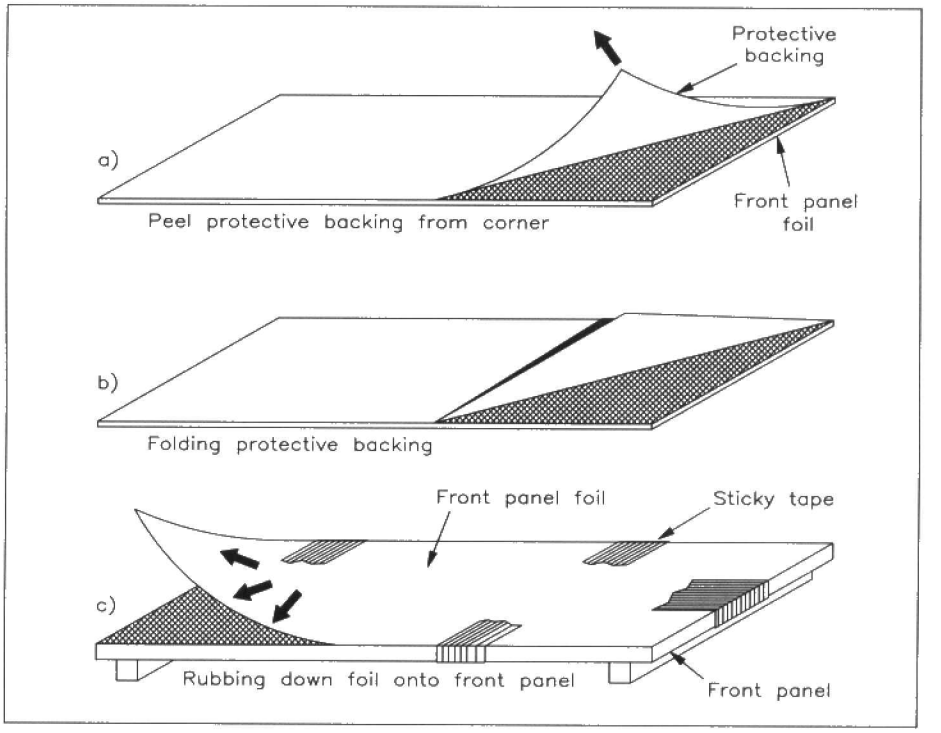


Figure 4. Applying the front panel foil.

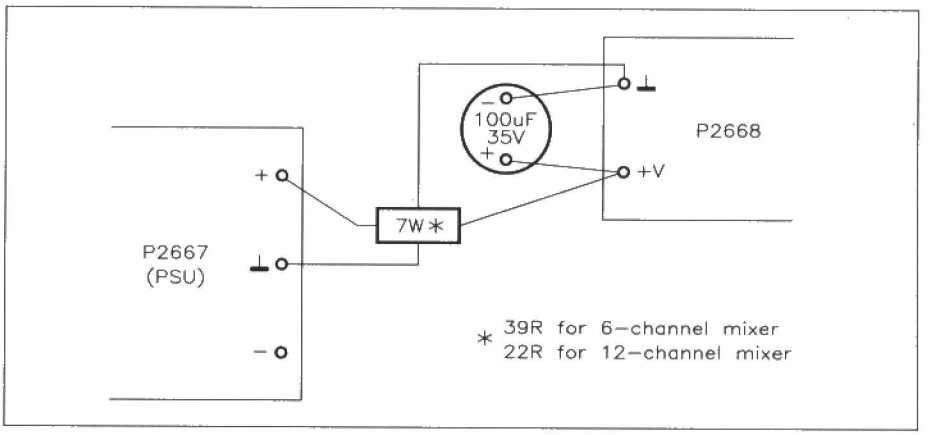
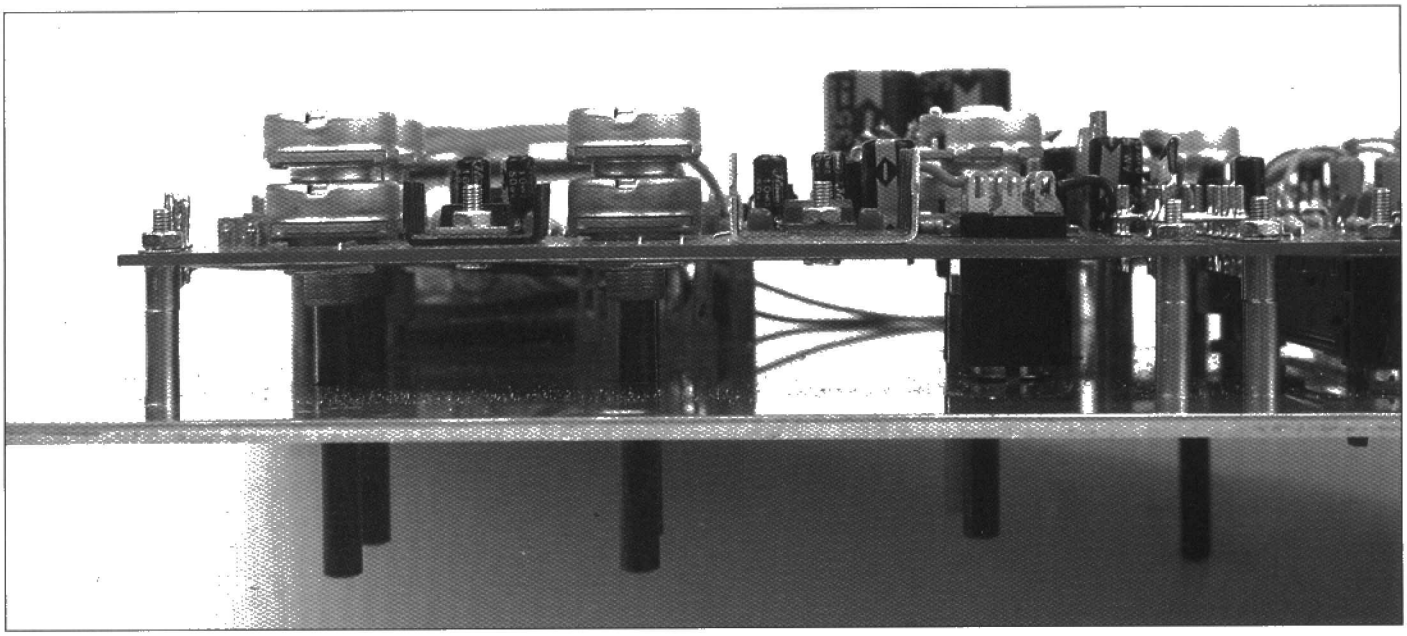


Figure 5. Adding power supply components for Dual Stereo VU Meters.



Side-view of 6-Channel Mixer. The Monitor and Effects Module is clearly visible.

fitted to the Master and Headphone Module earlier can now be soldered to the headphone socket.

Insert the neon rocker switch into the mixer panel, ensuring that the outer switch connections are closest to the edge of the mixer panel. Cut four 20mm lengths of CP64 heat-shrinkable sleeving, slide a piece of heat-shrinkable sleeving over each of the transformer primary leads (both coloured orange) and solder the leads to the switch contacts in the centre of the body. Slide the heat-shrinkable sleeving over the switch contacts and shrink using a heat source e.g., a lighter, hot-air gun, etc.

Interfacing the 6-Channel Mixer to the Outside World

Obtain or construct a suitable enclosure for the mixer panel. Fit the enclosure with suitable input and output sockets (which could be phono, mono or stereo ¼in. jack, or XLR sockets). If the enclosure to be used is conductive, the sockets will require insulating to prevent earth-loop problems. The XLR or stereo ¼in. jack sockets are normally used for balanced inputs (line or mic level), while mono ¼in. jack sockets are used for unbalanced microphones. Phono sockets are generally used for line level and turntable (record deck) inputs. At the end of the day, the choice is dictated by the configuration of the input modules which, in turn, is determined by individual system requirements. The Dual Stereo Fader Module provides, as you will remember from Issue 61 of 'Electronics', an 'autostart' output facility that may be used with certain turntables, cart machines, etc. Mono ¼in. jack sockets may be used for such outputs if they are required.

Connect appropriate lengths of screened cable – XR18U or XS39N for unbalanced inputs, and XR08J or XS40T for balanced inputs – between the input and output sockets and the relevant modules. If you are making use of the autostart facility, 16/0·2 wire should be used to link the sockets to the relevant Dual Stereo Fader Modules.

Install the mains cable into the enclosure and fix in place using a cable grommet (JR76H or LR48C). Connect the mains cable earth to the M5 solder tag mounted on the toroidal transformer; if the enclosure is constructed from metal, a second earth lead connected from the M5 solder tag to the enclosure will be required. Connect the mains cable live and neutral leads to the neon rocker switch and insulate using the previously-cut 20mm lengths of CP64 heat-shrinkable sleeving. Connect the input and output wiring to the appropriate modules.

Screw the completed mixer panel to the enclosure, and fit a 13A mains plug (fitted with a 2A fuse) to the mains lead. The mixer is now ready for testing.

Testing the 6-Channel Mixer

Ensure that all the gain and volume controls are fully anticlockwise, and that all sliders are set to '0'. The balance control and the tone controls should be set to the centre position (12 o'clock), the 'MASTER/PFL' switch set to 'PFL' and the STEREO/MONO switch set to 'STEREO'. When the power switch is in the 'off' (up) position, and the mains plug connected to a 13A outlet, the neon rocker switch should illuminate, indicating that the mixer is connected to a mains supply. When the power switch is pushed to the 'down' position, the LED should illuminate, indicating that a DC supply is present. Depending upon the input module configuration, connect a suitable signal source (preferably music of some kind) to one stereo input channel (i.e. both left and right channels) of the mixer. Turn the gain control clockwise until the overload indicator illuminates; note the position of the knob and turn it half-way anticlockwise – the LED should go off. Connect a pair of headphones to the headphone socket, turn the headphone volume up and the signal source should be heard. Turn the 'MASTER/PFL' switch to 'MASTER' and move the channel's 'PFL' toggle switch to the 'up' position; push the slide control up and turn the 'MASTER' volume control up. The signal should be heard from the headphones.

To check that the AUTO START facility works, connect a multimeter to the socket of the channel in question (the black lead of the meter to 0V), set the multimeter to a continuity or resistance measuring range, and move the relevant slide control forward. A bleep, or low resistance reading, should be obtained. If the fader module has been constructed to give a 'pulse' output, then a short bleep or a brief drop in resistance will be obtained. Set the slider control to zero, and the gain control fully anticlockwise. Repeat the above test for any other channels that use the autostart facility.

Leaving all the settings on the last channel as they are, we now turn our attention to the output side. Turn the BALANCE control to the left, and then to the right – this should cause the signal to pan to the left, and then to the right; once correct operation has been ascertained, reset the control to its centre position. Check that the BASS and TREBLE controls provide boost and cut in their respective frequency ranges. If the signal source and input module being used are stereo, set the STEREO/MONO toggle switch to mono – the signal from both headphones should be subjectively identical and equal in amplitude. Unless you want mono operation, reset this switch to its 'STEREO' position! Check that a signal is present on all 'HIGH', 'MEDIUM and 'LOW' output sockets. Finally, check that a signal is present at the left and right record outputs.

The mixer has now been fully tested, and is ready for use.

The 12-Channel Mixer

Before you can build a 12-Channel Mixer, you must ensure that all of the required modules (these were outlined earlier) are built up and tested wherever possible.

Building the 12-Channel Mixer

Most of the information given for the construction of the 6-Channel Mixer also applies to the 12-Channel Mixer. Therefore, even if you are building the 12-Channel Mixer, a read of the instructions given for the 6-channel version is imperative. However, there are important differences and these will be highlighted in the following section.

Specifications

Input Impedances

Phono:	47kΩ/180pF
Stereo Line:	47kΩ
Mono Line:	100kΩ balanced/47kΩ unbalanced
Microphone:	10kΩ balanced/5k6Ω unbalanced
Effect Return:	47kΩ

Input Sensitivities

Phono:	5 to 80mV RMS
Stereo Line:	100mV to 2·75V RMS
Mono Line:	50mV to 1·5V RMS
Microphone:	1mV to 30mV RMS
Effect Return:	775mV RMS

Signal-to-noise ratio (A-weighted)

Phono:	80dB
Stereo Line:	83dB
Mono Line:	81dB
Microphone:	80dB

Frequency Response

Phono:	RIAA curve ±1dB
Stereo Line:	20Hz to 100kHzm (−3dB)
Mono Line:	20Hz to 100kHz (−3dB)
Microphone:	20Hz to 15kHz (−3dB)

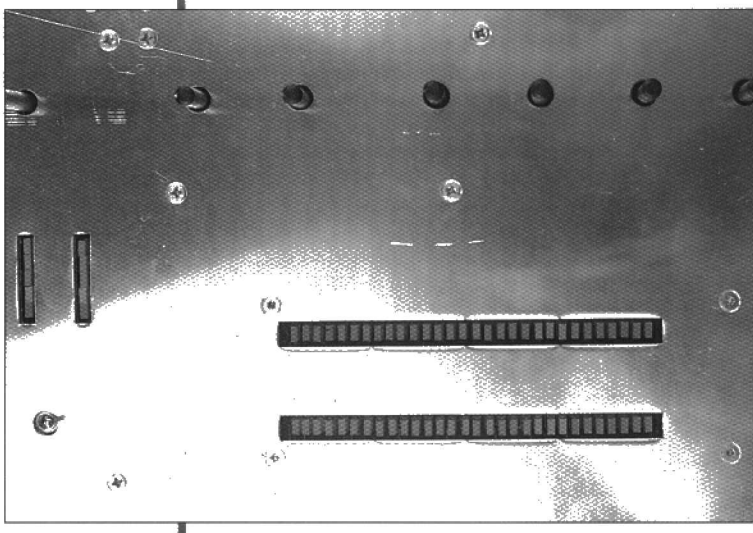
Output Impedance:	1kΩ
Autostart Open Collector Output:	24V DC @ 50mA (max.)

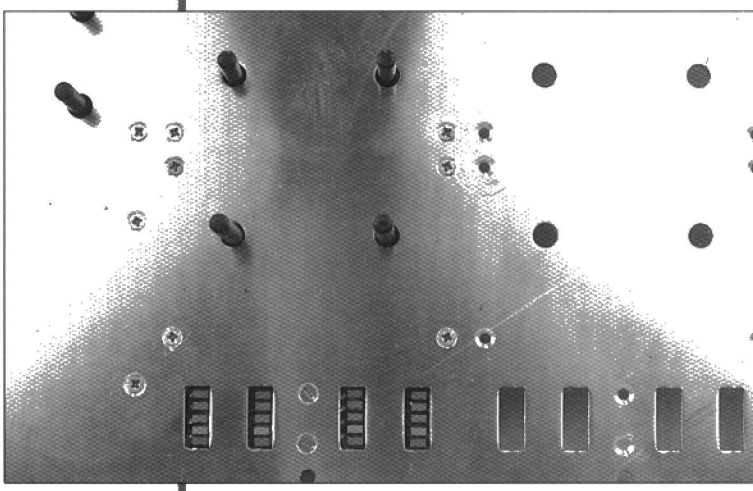
Tone Control

Per channel:	Bass	50Hz ± 12dB
	Middle	1kHz ± 15dB
	Treble	15kHz ± 12dB
Master:	Bass	50Hz ± 15dB
	Treble	15kHz ± 15dB
Monitor:	Centre Frequency	100Hz to 10kHz
	Q Factor	0·4 to 2·5
	Attenuation	0 to 30dB

Output Levels

Master:	0·775/1·5/2·5V RMS
Monitor:	0·775/1·5/2·5V RMS
Effect:	0·775V RMS
Tape Recorder:	0·775V RMS
Headphones:	0·1W (4Ω)/0·2W (8Ω)/0·4W (16Ω) 1·25W (32Ω)/0·5W (100Ω)/0·1W (400Ω)
Overload Limit:	7dB
Overload Indication:	3dB
Total Harmonic Distortion:	0·05%
Crosstalk (1 kHz):	45dB
Fader Range:	90dB





Top: Close-up view of 12-Channel Mixer's front panel, just prior to the application of the self-adhesive foil. The Precision VU Meter can be seen clearly.

Above: Another close-up view of the 12-Channel Mixer's front panel, this time concentrating on the Dual Stereo VU Meters that function as the input level indicators.

Begin construction of the mixer panel by inserting the countersunk screws from the front (i.e. control side) of the mixer panel. Fit the M3 x ¼in. spacers over the screws, followed by the M3 threaded spacers, for all the PCB positions except those of the Dual Stereo VU Meter Modules – the latter has its own set of mounting hardware, supplied in its kit. In addition, use only the threaded spacers with the M3 x 6mm countersunk screws for mounting the Precision VU Meter.

Bolt the toroidal mains transformer into position using the M5 x 40mm countersunk screw, as shown in Figure 3. Clean the mixer panel using a suitable solvent (such as methylated spirit) to remove any dust and grease. Place some blocks under the the mixer panel so that it can be positioned horizontally facing upwards. The front panel foil can now be attached using the methods described for the 6-Channel Mixer.

The control knob shafts should be trimmed as described for the 6-Channel Mixer; exactly the same methods are used – there are just more modules involved!

At this stage, all the modules except the Precision VU Meter and Master Module can now be permanently installed. Attach short lengths of wire to the Master and Headphone Module for the headphone socket connections, as shown in the manual supplied with the module; once these wires have been soldered in place, it can be installed. Solder short lengths of screened cable (long enough to connect to the Master and Headphone Module) to the left and right inputs of the Precision VU Meter, and two short lengths of 16/0·2 hook-up wire to the supply inputs; this module can now be installed.

Make the PFL L/R, MIX L/R and +V/0/–V connections between each of the Dual Fader and Master and Headphone Modules using tinned copper wire, followed by the IN/OUT L/R and +V/0/–V connections between the Dual Input, Dual Tone Control and Dual Fader Modules. Link the EFF and MON +V/0/–V pins between the Dual Tone Control, Monitor and Effects, and Master and Headphone Modules. Solder the two screened leads from the Precision VU Meter to the VU OUT L/R pins of the Master and Headphone Module; note that the screen of the cable is only connected at the meter end.

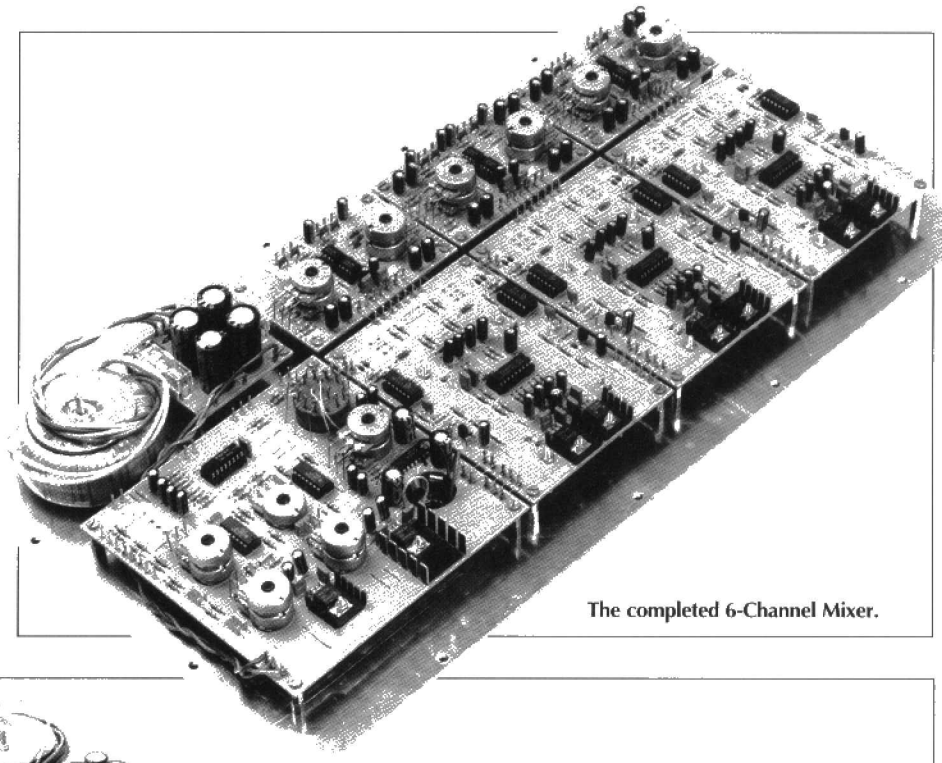
Connect the TO MIX L/R pins of the Monitor and Effects Module to the MIX L/R pins of the Master and Headphone Module using suitably-coloured 16/0·2 wire.

Using 4-core overall screened cable, connect the two sets of L/R IN pins of each

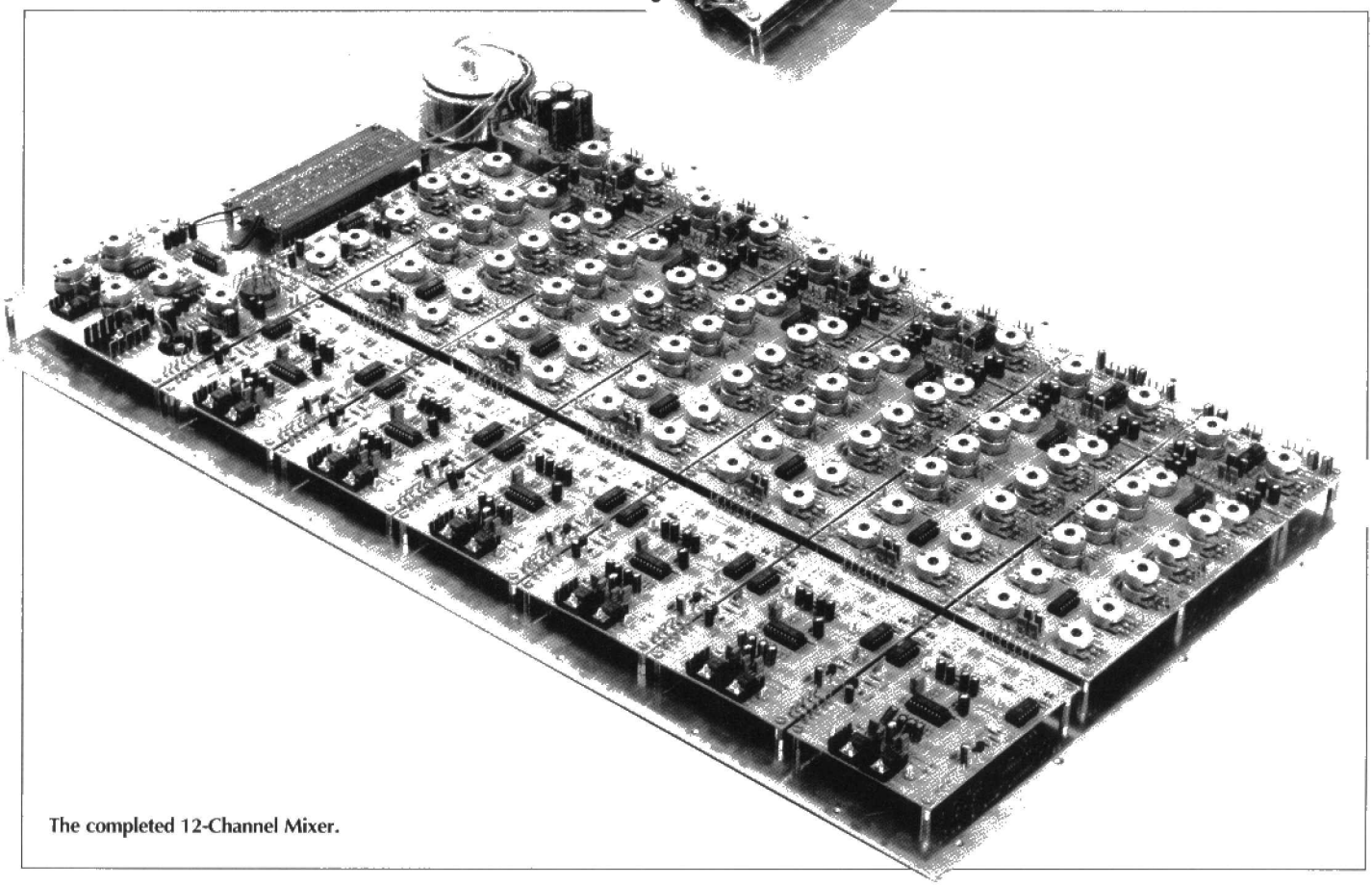
Dual Stereo VU Meter Module to the relevant L/R OUT pins of the nearest Dual Input Module. The screen of the cable is connected to the 0V pin of the input module only. Power supply arrangements, as described for the 6-Channel Mixer earlier, must be made for each Dual Stereo VU Meter. Note, however, that the 7W resistor in this case has a slightly lower value of 22Ω; this is to allow for the extra load of the additional three Dual Stereo VU Meters.

The mains transformer can now be connected to the PSU Module; the red wire should be soldered to the 'A' terminal, the yellow wire to the 'B' terminal, blue to 'C' and grey to 'D'.

Check, using a multimeter set to its highest resistance range, that there is no connection between the aluminium front panel and the power supply rails (i.e. +V/0/–V). Fit the headphone socket (note that only the HF93B or BW80B jack sockets will fit the front panel); the wires



The completed 6-Channel Mixer.



The completed 12-Channel Mixer.

fitted to the Master and Headphone Module earlier can now be soldered to the headphone socket.

Turning our attention to the busy fascia of the 12-Channel Mixer, we can now fit the knobs to the rotary switch and potentiometer spindles. The colour of the cap is determined by the control's application: headphone VOLUME and OUT/PFL/MON/EFF select knobs, black; GAIN and master VOLUME knobs, red; BASS, MIDDLE and TREBLE knobs, white; EFFECTS, LEVEL and RETURN, grey; MONITOR, ATT, BANDWIDTH, FREQ and LEVEL knobs, blue; BALANCE knobs, yellow. The slider knobs require modification; enlarge the slot to 2 x 11mm to enable them to be fitted over the slider spindles. Alternatively, the complete 'official' set of knobs (VX01B, including correct-fitting slider knobs!) is available, although it is somewhat more expensive.

The next stage is to construct or obtain a suitable enclosure for the mixer panel, and then to fit (and connect up) the required socketry. Refer to the details given earlier for the 6-Channel Mixer.

Fit a neon rocker switch to the rear of the enclosure. Install the mains cable into the enclosure and fix in place using a cable grommet (e.g., JR76H or LR48C). Connect the live and neutral leads of the mains lead to the contacts on the edge of the switch, and insulate using 20mm lengths of CP64 heat-shrinkable sleeving. Connect the primary of the mains transformer to the switch and insulate with heat-shrinkable sleeving. Connect the earth of the mains cable to the M5 solder tag mounted on the toroidal transformer; if the enclosure is constructed from metal, a second earth lead connected between the M5 solder tag and the enclosure will be required. Screw the completed mixer panel to the enclosure, fit a 13A mains plug to the mains lead and install a 2A fuse in the plug.

The 12-Channel Mixer is now ready for testing.

Testing the 12-Channel Mixer

Most of the tests are as for the 6-Channel Mixer, except that the additional complexity of its 12-channel brother changes procedures somewhat. In particular, the modules unique to the 12-Channel Mixer (Dual Tone Control, Precision VU Meter, etc.) also need to be tested.

When testing the headphone monitoring

circuitry, bear in mind that the rotary switch also selects effects monitor or return, in addition to master and PFL monitoring.

Applying a sound source (ideally music), check that the BASS, MIDDLE and TREBLE controls of the first channel each have an appropriate effect, and check that the BAL/PAN control (above the TREBLE control of each channel) pans to the left and right when suitably adjusted. Set the slider control to 0 and the gain control fully anticlockwise.

Testing the Effects Loop

Set the OUT/PFL/MON/EFF to MON and turn the first channel's MONITOR control, and the MONITOR LEVEL control (in the Monitor group of controls) up. A mono signal should be heard. Check that the BANDWIDTH, FREQUENCY and ATTenuator controls operate by nulling out part of the signal (refer to the Monitor and Effects Module article in Issue 62 of 'Electronics'), which will be most noticeable at low frequencies. Turn the input channel MONITOR, and the MONITOR LEVEL, controls to 0. Linking the EFFECT OUT and EFFECT RETURN sockets together using a suitable lead, turn the OUT/PFL/MON/EFF switch to EFF, and turn the EFFECT, EFFECT LEVEL and RETURN controls up; again, a mono signal should be heard. Turn the EFFECT, LEVEL and RETURN controls to 0.

Repeat the above test for the other 11 channels (phew!); Since the ATT, BANDWIDTH, FREQUENCY and LEVEL controls of the Monitor and Effects Module have just been tested, there is no need to do it for the remaining 11 channels – unless you want to, of course!

When testing of the effects loop has been completed, the lead linking the EFFECT OUT and EFFECT RETURN sockets can be removed.

Once the master tone/balance controls, mono switching and rear-panel output socketry have been tested, as per the 6-Channel Mixer, the unit is ready for use.

6-CHANNEL MIXER PARTS LIST

6-Channel Front Panel	1	(VE39N)
Dual Input Amplifier Module	3	(VE30H)
Dual Fader Module	3	(VE31J)
Master and Headphone Module	1	(VE33L)
Mixer PSU Module	1	(VE36P)
Dual Stereo VU Meter Module	3	(VE38R)
Toroidal Transformer 30VA 2 x 12V	1	(YK12N)
Spacer M3 x ¼in.	4 Pkts	(FG33L)
Threaded Spacer M3	4 Pkts	(FG38R)
Steel Screw M3 x 6mm	4 Pkts	(JY21X)
Pozi Screw M3 x 10mm	4 Pkts	(LR57M)
Pozi Screw M5 x 40mm	1 Pkt	(JC81C)
Isotag M5	1 Pkt	(LR62S)
Isoshake M5	1 Pkt	(BF42V)
Switch Red Neon	1	(KU99H)
LED Red 5mm	1	(WL27E)
LED Clip 5mm Concave	1	(UK15R)
Resistor 47k 0·6W	1	(M47K)
Resistor 47Ω 7W	1	(L47R)
PC Electrolytic Capacitor 1000µF 35V	1	(FF18U)
Slide Knob Type F Black	6	(RX24B)
Knob 15mm Collet 6	12	(JZ50E)
Cap 15mm Red	7	(JZ68Y)
Cap 15mm Yellow	1	(JZ70M)
Cap 15mm Blue	2	(JZ71N)
Cap 15mm White	2	(JZ72P) or (VX00A) (see text)
Wire 16/0·2 10m Red	As Req.	(FA33L)
Wire 16/0·2 10m Green	As Req.	(FA29G)
Wire 16/0·2 10m Black	As Req.	(FA26D)
Wire TC 0·71mm 22swg	As Req.	(BL14Q)
Cable Grommet	As Req.	(JR76H) (or LR48C)
Min Mains Black	As Req.	(XR01B)
Heat-Shrinkable Sleeving CP64	As Req.	(BF90X)
Screened Cable	As Req.	(e.g., XR18U)
Lapped 4-Core Grey	As Req.	(XR92A)
Twin Microphone Cable	As Req.	(e.g., XR08J)
Chassis-Mounting Phono Socket	As Req.	(e.g., YW06G)
XLR Chassis Socket	As Req.	(e.g., BW90X)
XLR Chassis Plug	As Req.	(e.g., BW92A)
Stereo Chassis Jack Socket ¼in.	See text	(HF93B) (or BW80B)
Stereo Chassis Jack Socket ¼in.	As Req.	(e.g., HF92A)
Mono Chassis Jack Socket ¼in.	As Req.	(e.g., HF91Y)

12-CHANNEL MIXER PARTS LIST

12-Channel Front Panel	1	(VE40T)
Dual Input Amplifier Module	6	(VE30H)
Dual Fader Module	6	(VE31J)
Dual Tone Control	6	(VE32K)
Master and Headphone Module	1	(VE33L)
Monitor and Effects Module	1	(VE34M)
Precision Stereo VU Meter Module	1	(VE38R)
Mixer PSU Module	1	(VE36P)
Dual Stereo VU Meter Module	6	(VE38R)
Toroidal Transformer 50VA 2 x 12V	1	(YK15R)
Spacer M3 x ¼in.	10 Pkts	(FG33L)
Threaded Spacer M3	11 Pkts	(FG38R)
Steel Screw M3 x 6mm	11 Pkts	(JY21X)
Pozi Screw M3 x 6mm	1 Pkt	(BF36P)
Pozi Screw M3 x 10mm	10 Pkts	(LR57M)
Pozi Screw M5 x 40mm	1 Pkt	(JC81C)
Isotag M5	1 Pkt	(LR62S)
Isoshake M5	1 Pkt	(BF42V)
Switch Red Neon	1	(KU99H)
Resistor 22Ω 7W	1	(L22R)
PC Electrolytic Capacitor 1000µF 35V	1	(FF18U)
Slide Knob Type F Black	12	(RX24B)
Knob 15mm Collet 6	96	(JZ50E)
Cap 15mm Red	13	(JZ68Y)
Cap 15mm Yellow	13	(JZ70M)
Cap 15mm Blue	16	(JZ71N)
Cap 15mm White	38	(JZ72P)
Cap 15mm Grey	14	(JZ73Q)
Cap 15mm Black	2	(JZ76H) or (VX01B) (see text)
Wire 16/0·2 10m Red	As Req.	(FA33L)
Wire 16/0·2 10m Green	As Req.	(FA29G)
Wire 16/0·2 10m Black	As Req.	(FA26D)
Wire TC 0·71mm 22swg	As Req.	(BL14Q)
Cable Grommet	As Req.	(JR76H) (or LR48C)
Min Mains Black	As Req.	(XR01B)
Heat-Shrinkable Sleeving CP64	As Req.	(BF90X)
Screened Cable	As Req.	(e.g., XR18U)
Lapped 4-Core Grey	As Req.	(XR92A)
Twin Microphone Cable	As Req.	(e.g., XR08J)
Chassis-Mounting Phono Socket	As Req.	(e.g., YW06G)
XLR Chassis Socket	As Req.	(e.g., BW90X)
XLR Chassis Plug	As Req.	(e.g., BW92A)
Stereo Chassis Jack Socket ¼in.	See text	(HF93B) (or BW80B)
Stereo Chassis Jack Socket ¼in.	As Req.	(e.g., HF92A)
Mono Chassis Jack Socket ¼in.	As Req.	(e.g., HF91Y)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

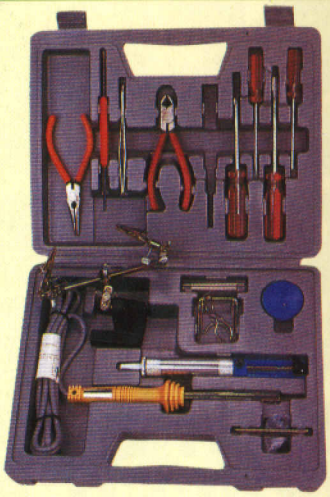
Order As VE39N (6-Channel Front Panel) Price £49.95
Order As VE40T (12-Channel Front Panel) Price £99.95
Order As VX00A (Control Knob Set 6-Channel) Price £17.95
Order As VX01B (Control Knob Set 12-Channel) Price £89.95
Order As VE38R (Dual Stereo VU Meter Module) Price £20.95

HOBBYIST STARTER TOOL KIT

Selected to suit the typical needs of the new electronics hobbyist, it is presented in a cloth tool roll and contains the following: Soldering kit with soldering iron, iron stand and a pack of solder, desoldering tool, side cutters, long nosed pliers, flat blade screwdriver and a crosspoint screwdriver.

Order Code SK01B [B] **£24·95**

STUDENTS TOOL KIT



A 15-piece set, selected for electronics courses at schools and colleges or the electronics hobbyist. It includes a 25W soldering iron with two interchangeable bits, iron stand, desoldering tool, a supply of solder and a pot of flux, wire wrap tool, two crosspoint and two flat blade screwdrivers, wire cutters, pliers, and for delicate or PCB work, a 'Helping Hands' and a pair of tweezers. The kit is housed in a sturdy plastic case with a carry handle and two catches, the individual tools are held in compartments which prevent them from moving during transit.

Order Code BZ60Q [B] **£19·95**

Excellent value tool kits designed with the electronics hobbyist in mind, but also suitable for a wide range of general purpose uses.

WHEN A JOBS WORTH DOING...

ADVANCED TOOL KIT

Housed in a large, robust, plastic box with a removable tray, the Advanced Tool Kit, comprises side cutters, long nosed pliers, 100mm long flat blade light duty screwdriver, 75mm long chrome-vanadium 5mm flat blade screwdriver, size 0, 1 and 2 crosspoint drivers, easy-to-use combined wire cutter and stripper, Soldering kit with soldering iron, iron stand and a 5m pack of solder.

Order Code SK02C [D] **£29·95**

ENGINEER'S TOOL KIT

A very comprehensive selection, housed in a large plastic box with a removable tray, and comprises: side cutters, long-nosed pliers, heavy-duty electricians pliers, 75mm long chrome vanadium 5mm wide flat blade screwdriver, a set of long shaft screwdrivers (two flat blade and one crosspoint), light duty 100mm long flat blade screwdriver, 75mm long size 1 crosspoint driver, 100mm long size 2 crosspoint driver, a cased 11-piece precision screwdriver set, a preset trimmer tool, a retractable blade knife, combined wire stripper and cutter tool, junior hacksaw, needle file set, 6 in. stainless steel rule, desoldering tool, Soldering kit with soldering iron, iron stand and 5m pack of solder.

Order Code SK03D [D] **£46·95**

...IT'S WORTH DOING WELL!

All items are subject to availability. All prices include VAT. Handling Charge £1·20. [B] indicates carriage charge of £2. [D] indicates carriage charge of £3·05. Prices subject to change. Overseas orders please phone 0702 552911 in first instance. Visit your local Maplin store in: **BIRMINGHAM;** Sutton New Road, Erdington. **BRIGHTON;** 65 London Road. **BRISTOL;** 302 Gloucester Road. **CARDIFF;** 29-31 City Road. **CHATHAM;** 2 Luton Road. **COVENTRY;** 12 Bishop Street. **EDINBURGH;** 126 Dalry Road. **GLASGOW;** 264-266 Great Western Road. **ILFORD;** 302-304 Green Lane. **LEEDS;** Carpet World Building, 3 Regent Street. **LEICESTER;** Office World Building, Burton Street. **LONDON;** 146-148 Burnt Oak Broadway, Edgware. 107-113 Stanstead Road, Forest Hill. 120-122 King Street, Hammersmith. **MANCHESTER;** 8 Oxford Road. **NEWCASTLE-UPON-TYNE;** Unit 4, Allison Court, The Metro Centre, Gateshead. **NOTTINGHAM;** 86-88 Lower Parliament Street. **PORTSMOUTH;** 98-100 Kingston Road. **READING;** 129-131 Oxford Road. **SHEFFIELD;** 413 Langsett Road, Hillsborough. **SOUTHAMPTON;** 46-48 Bevois Valley Road. **SOUTHEND-ON-SEA;** 282-284 London Road, Westcliff. Plus a NEW STORE opening soon in **MIDDLESBROUGH** Phone **0702 552911** for further details.

Maplin ELECTRONICS

CREDIT CARD HOTLINE

0702 554161

Mail Order to:
P.O. Box 3, Rayleigh, Essex, SS6 8LR.